AN INITIAL POPULATION ANALYSIS AND MANAGEMENT STRATEGY FOR KENAI PENINSULA BROWN BEARS

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

Increasing human activity and land development on the Kenai Peninsula, Alaska has brought about concern for the brown bear (Ursus arctos) population. The human population of the Kenai Peninsula has increased from 24,600 in 1977 to 43,000 in 1986. Because some human activities cause displacement and loss of critical habitat, research was proposed to address the situation and develop a management strategy to maintain a viable population size.

This document analyzes data collected from research conducted on the brown bear population and presents a management strategy. The data were collected from 1984 through 1987 and consisted of ground surveys to identify areas of brown bear use along salmon streams, aerial surveys, public observations, relocations of radio collared bears and harvest data.

The peninsula had an area of 23,310 km^2 with approximately 8800 km^2 of land used regularly by brown bears. This represented areas that bears or their sign were most frequently observed. Estimates of the brown bear population size on the peninsula were thought to be 150 to 250 by ADF&G and USFWS biologists, but were not based on capture-recapture techniques.

Relocations

Bears seemed to move randomly during the spring as spring bear foods were widely distributed across the peninsula. Carrion from winter/wolf-killed moose or caribou attracted collared bears and large movements to carcasses were observed. Use of salmon streams were clearly important for brown bears during the summer and fall. Between 1 July and 1 October, 73% of the relocations were on or very near salmon streams.

Annual home range sizes for males (949.6 km^2) were more than twice as large on the average as females (401.2 km^2). Home range sizes that were this large tended to overlap human developments which made bears more susceptible to human/bear conflicts. Males spent an average of 144 days in the den while females spent an average of 168 days. Den sites were located on similar slopes for both males and females (19.5°), and mean den site elevations were 389 m and 650 m for males and females, respectively.

Observations

Brown bear observations from aerial surveys, ground surveys, and public sightings were used to estimate average litter sizes. Average litter size for females with cubs was 1.7; with yearlings was 1.9; and subadults was 2.0. When all age classes were pooled the weighted average litter size was 1.81.

Ground Surveys

Ground surveys supplied information about the distribution of brown bears across the peninsula. The areas of greatest use were: 1) Benchlands between Skilak Lake and Tustumena Lake, 2) Headwaters of Deep Creek, Ninilchik River, Anchor River and Fox River, 3) Chickaloon River drainage, 4) South Fork of the Snow River and 5) Johnson and Bench Lake area.

Based on track counts of 25 salmon streams, an average of 2.6 bears (range = 0-11) used a particular salmon stream at any one time. Large concentrations of bears using a salmon stream were not observed. Staple spring foods, grasses, sedges and horsetail were present in all of the 12 habitat surveys conducted.

Aerial Surveys

An average of 1.3 brown bears/hour were observed during 87.3 hours of aerial surveys. The highest rate of bears per hour were observed during the month of July (1.99 bears/hour).

Mortality

Annual mortality of brown bears had nearly doubled from 6.4/year to 13.2/year in the last nine years. Seventy-nine percent of all harvested bears were killed during the moose season. Brown bear harvest was considered incidental to the moose harvest, therefore, an increase in the bear harvest was most likely a result of an increase in moose hunters during the last nine years. A spring brown bear season was added in game management unit (GMU) 15 and GMU 7 in 1978 and 1980, respectively, which increased total harvest numbers. The increase in yearly brown bear season length and access into hunting areas have also contributed to an increase in the harvest.

The sex ratio had shifted with the increase in the harvest. From 1970-1978 the sex ratio of harvested bears was (male:female) 1.5:1, and was 0.9:1 from 1979-1987. Age distribution had fluctuated and did not follow a trend. Males were consistently the oldest bears in the harvest ranging from 1.5 to 28.5, while females ranged from 1.5 to 17.5.

Bears killed in defense of life or property (DLP) had not significantly increased from 1961 to 1987. Sex ratio among DLP deaths was 0.9:1. DLP's occurred between April and November but most frequently in the late spring and early fall.

One of 4 bears tagged in 1978 and 3 of 13 bears tagged from 1984-1986 were killed in the reported harvest. This represented at least a 23% return.

Using Bunnell and Tait's (1980, 1981) model, maximum sustained mortality for the Kenai population was calculated to be approximately 12% annually. By subtracting 5% natural mortality, 7% mortality could be caused by humans. This included harvest, DLP, illegally killed and unreported kills. Three scenarios using population estimates from 100 to 300 provided a range of allowable human-caused mortalities from 7 to 21 bears/year. The average estimate for the brown bear population was 200 bears, thus the estimated maximum number of human-caused mortalities per year was 14. Unreported and illegal kill rates were estimated by Brannon et al. (1988) and would translate to 1-2 bears per year when applied to the Kenai harvest. Once these were subtracted the reported mortality estimate was 12-13 bears per year. The average number of bears harvested on the peninsula was 16.3 per year from 1985-1987. Thus the Kenai harvest may be at or exceeding the recommended mortality rate.

RCR Trail Survey

The Russian River / Cooper Lake / Resurrection River (RCR) trail system was the heaviest used trail by visitors to the peninsula. The trail system receives approximately 5800 visitors per year. Use of the trail by campers and hikers did not change significantly from 1984 through 1986. Brown bear encounters/observations with hikers averaged 7 per year. The area the trail traversed between lower and upper Russian Lakes was the most common place (86%) that campers and hikers encountered/observed brown bears.

Conclusions and Recommendations

1) Although data were limited, the brown bear population seemed to be at a low density. Future brown bear research should be directed at estimating the population size and density by using capture-recapture techniques, although collecting a suitable sample size will be a formidable task on the Kenai Peninsula.

2) Encroachment on essential habitat through road construction and land development was shrinking current brown bear range by displacement or harassment. Although DLP's had not significantly increased, the potential for conflicts will increase as encroachment on essential habitat continues. The peninsula should be zoned according to areas that are essential, secondary or corridor, and nonessential to brown bears. Each zone should have specific management recommendations with regard to potentially negative impacts on the brown bear population. Protection of salmon spawning sites used by brown bears should be foremost.

3) The harvest was increasing because of increased hunting pressure, longer season length, and easier access. The mean number of reported brown bear mortalities from 1985-1987 exceeded an estimated maximum human-caused mortality rate for a population size of 200 bears. Because the proportion of females in the harvest increased to

greater than 50%, this may indicate heavy hunting pressure on the population.

The harvest should be modified to reduce the total brown bear harvest and reduce the number of females killed. I recommend a maximum of 10-11 reported bear mortalities per year, ≥60% male, to improve our margin of error until more definitive population data are available. This could be accomplished by shifting the harvest later into the fall and prohibiting the killing of any bears in family groups. Placing quotas on the number of bears harvested with a female subquota, or closing the fall hunting season would be other methods used to accomplish the management objectives.

4) The RCR trail system was located in essential brown bear habitat. Brown bears used the area during the spring, summer and fall. The trail should be monitored for visitor use at 3-5 year intervals and human/bear encounters recorded to detect trends. Using a Limits of Acceptable Change (LAC) format to determine the character and direction of future recreational activities on the trail system will determine the fate of the brown bear in this essential area. Other trails on the peninsula, where the potential for human/bear conflicts exists, should also undergo LAC evaluation.

INTRODUCTION

Human activity and increased land development on Alaska's Kenai Peninsula has increased concern for the brown bear (Ursus arctos) population. During the past 40 years human activity has been reducing historic brown bear range on the peninsula (Bevins et al. 1985). As humans encroach on current brown bear range, defense of life and property (DLP) conflicts and subsequent displacement of the bears will continue (Schallenberger 1980, Zager et al. 1983, Gunther and Renkin 1985, Schoen and Beier 1987). Because displacement is equated with a loss of suitable habitat, foremost concern is for maintaining enough habitat to support a viable population of brown bears.

Brown bears on the Kenai Peninsula are managed by the Alaska Department of Fish and Game (ADF&G) and the Kenai National Wildlife Refuge (KNWR). The land on which they range is managed by state and federal agencies, native organizations and private individuals. The federal land management agencies include the United States Fish and Wildlife Service (USFWS) at KNWR, the United States Forest Service (USFS) at Chugach National Forest (CNF), and the National Park Service (NPS) at Kenai Fjords National Park

(KFNP).

Because of rapid land use changes on the peninsula the USFWS proposed a study in 1983 to gather baseline information about brown bears on the KNWR. On 6 January 1984, representatives from the USFWS, USFS and ADF&G attended a meeting at the KNWR headquarters in Soldotna to discuss the proposal. They agreed that more information was needed and formed the Interagency Brown Bear Study Team (IBBST). A memorandum of understanding for a cooperative study was endorsed by the 3 agencies in July, 1984. The IBBST conducted field research through 1987.

The IBBST determined information needs and discussed the logistics of various study plans. The study team developed a step-down plan which outlined the research necessary to accomplish specific goals (Bevins et al. 1985). The research efforts included:

1) A limited effort to radio-collar bears during the summer and fall of 1984. The initial effort determined the feasibility of a more intensive study the following year.

2) An extensive review of the literature and interviews with long-time residents to gather background information pertaining to Kenai Peninsula brown bears.

3) Aerial and ground surveys in areas that had known or suspected high-use by brown bears.

4) A determination of human and bear use and interactions on the Russian River / Cooper Lake / Resurrection

River (RCR) trail system.

5) Collection of data to develop a management strategy and make management recommendations on those activities that potentially result in negative impacts to brown bears.

The ultimate goal is to have the agencies endorse another memorandum of understanding stating their mutual objectives for managing brown bears and their habitat on the Kenai Peninsula. These objectives would include retaining a viable population of brown bears and giving serious consideration to impacts on their habitat prior to finalizing any land management decision or regulatory action.

Agreement among the IBBST agencies, on a management strategy for bears would greatly increase the chances for maintaining a healthy population. This document discusses the analysis of data gathered from 1961-1987, and presents a management strategy based on the results of the analysis, current literature, and biological intuition.

STUDY AREA

Physiography

The Kenai Peninsula has an area of 23,310 km^2, and is located in south central Alaska between north latitude 59°-61° and west longitude 148°- 152° (Fig. 1). It is bounded on the west by Cook Inlet, on the east by Prince William Sound and on the south by the Gulf of Alaska. It is connected to mainland Alaska by a narrow strip of land 17.7 km wide (Spencer and Hakala 1964, Peterson et al. 1984, Oldemeyer and Regelin 1987). The major physiographic land form occupying the eastern two-thirds of the peninsula is the rugged, heavily glaciated Kenai Mountains. Elevations range from sea level to 2,000 m. The northwestern third is dominated by the Kenai lowlands, a glaciated plain dotted with numerous lakes (Spencer and Hakala 1964).

The climate of the plain has characteristics of both continental and maritime zones, although moderating influences from the Cook Inlet diminish rapidly with increasing distance from the coast. Annual precipitation ranges from 40 - 50 cm and is evenly distributed throughout the year (Bangs and Bailey 1980). Snow cover generally lasts from November through April, however, winter thaws and rain are common. Annual snowfall ranges from 140 to 165 cm

Figure 1. Location map for the Kenai Peninsula, Alaska.

(Oldemeyer and Regelin 1987). The growing season averages 88 days (range 67 - 133), usually beginning 11 June and ending 6 September (Spencer and Hakala 1964). Temperatures are more moderate than interior Alaska, and range from as low as -30°C to as high as 21°C (Smith 1984) with a mean annual temperature of 1°C (Sigman 1977).

Vegetation

Vegetation types include alpine tundra, treeless bogs, low growing spruce forests, interior spruce-hardwood forests and coastal spruce-hemlock forests (Viereck and Little 1972).

Coastal areas are forested by dense stands of Sitka spruce (*Picea sitchensis*), western hemlock (*Tsuga heterophylla*) and mountain hemlock (*Tsuga mertensiana*). Black cottonwood (*Populus trichocarpa*) is common along some of the glacial outwash streams. Extensive mud flats and sedge (*Carex spp.*) meadows occur along the Chickaloon Flats on the northern tip of the peninsula and at the head of Kachemak Bay.

Shrub thickets include alder (*Alnus crispa*), red elder (*Sambucus racemosa*) and devil's club (*Oplopanax horridum*) and are common on steep hillsides and along avalanche chutes. Shrub alder thickets typically occur above tree line (500 m) and give way to alpine tundra with an increase in elevation. Alpine vegetation includes white mountainavens (*Dryas octopetala*), dwarf arctic birch (*Betula nana*), crowberry (*Empetrum nigrum*), dwarf blueberry (*Vaccinium caespitosum*), and mountain-cranberry (*Vaccinium vitus-idaea*) Approximately 40% of the Kenai Mountains are covered by active glaciers where pioneering plants along the edges of receding glaciers are the only vegetation.

Low growing spruce forests are intermixed with treeless bogs in much of the western side of the peninsula. The lowlands are a typical interior boreal forest containing a mixture of black spruce (*Pices mariana*) with some white spruce (*Pices glauca*), and paper birch (*Betula papyrifera*). Common shrubs include Labrador-tea (*Ledum groenlandicum*), scouler willow (*Salix scouleriana*), rusty menziesia (*Menziesia ferruginea*) and Barclay willow (*Salix barclayi*). Southwestern lowlands include subalpine grass-forb-alder meadows and riparian and subalpine willow shrublands. Sedge/grass meadows are intermixed with horsetail (*Equisetum spp.*) and willows occur in poorly drained areas.

On dry upland sites in the northern half of the peninsula the mature forest vegetation is white spruce, paper birch, poplar (*Populus balsamifera*), aspen (*Populus tremuloides*) or some combination of these species, while black spruce dominates poorly drained sites (Lutz 1956, Spencer and Hakala 1964). The deciduous tree species represent successional stages of revegetation after fires. The understory associated with these successional stages likewise follow patterns of succession. Shortly after a fire a lush herb layer is established, with fireweed (*Epilobium angustifolium*) and bluejoint (*Calamagrostis canadensis*) most common. Depending upon the severity of the fire, shrub species (*Salix*, *Ledum*, and *Vaccinium*) reinvade 6-25 years following the burn. As the overstory component matures, many of the understory species are shaded out leaving the more shade-tolerant forbs like highbush cranberry (*Viburnum edule*) and twinflower (*Linnaea borealis*), with scattered areas of rusty menziesia and devil's club.

Terrestrial Mammals and Anadromous Fish

Brown bears share the Kenai Peninsula with 6 other indigenous large mammals. Moose (*Alces alces*) are common throughout the peninsula, seasonally occupying habitats from the lower slopes of the Kenai mountains to the flatlands. Caribou (*Rangifer tarandus*) occupy more open habitats and are less common. Black bears (*Ursus americanus*) and wolves (*Canis lupus*) occur throughout the area. Dall sheep (*Ovis dalli*) and mountain goats (*Oreamnos americanus*) are present in suitable habitat throughout the Kenai Mountains. Other mammals include: lynx (*Felis lynx*), coyote (*Canis latrans*), wolverine (*Gulo gulo*), mink (*Mustela vison*), river otter (*Lutra canadensis*), muskrat (*Ondatra zibethicus*), beaver (*Castor canadensis*), porcupine (*Erethizon dorsatum*), snowshoe hare (*Lepus americanus*) and red-backed vole (*Clethrionomys rutilus*). Five species of Pacific salmon (*Oncorhynchus spp.*) spawn in streams on the Kenai Peninsula. Run timing, salmon abundance and species composition vary between drainages.

Human Population

In 1986, the Kenai Peninsula had 43,000 permanent residents; a 75% increase from the 1977 estimate of 24,600 (S. Stedmon, Pers. comm.). Most residents live in or near the cities of Kenai, Soldotna and Homer on the western side of the peninsula. Residents of Anchorage (1980 population, 204,000) frequently visit the peninsula for a variety of recreational and commercial activities. The area is also used by thousands of non-Alaskan visitors annually, primarily during the summer. The economy of the peninsula is diverse. Principal sources of income include oil and gas extraction, commercial fishing, fish processing, recreation, tourism, timber harvesting, and transportation.

METHODS

A detailed account of the field methods used by the IBBST was described in each of the annual research reports (Bevins et al. 1985, Risdahl et al. 1986, Schloeder et al 1987, Jacobs et al. 1988). A brief summary follows.

Tagging Efforts and Telemetry Data

Brown bears were captured by firing immobilization darts from a helicopter or by snaring. Aldritch foot snares were used along salmon streams following a technique used by John Schoen (ADF&G-Juneau). We attempted to capture only adult bears. Etorphine hydrochloride (M99) and its antagonist diprenorphine (M50-50) (Lemmon Co., Sellersville, PA.) were used to immobilize and awaken 5 of 19 bears. Phencyclidine hydrochloride (sernylan) (Bioceutic Laboratories, St. Joseph, MO.) was used to immobilize the others. Bears were tagged using standard procedures (Schwartz et al. 1983).

Relocations

Captured individuals were fitted with Telonics radio-collars equipped with an inverse mortality mode set to slow the pulse rate 10 minutes after the bear became inactive.

Pulse rate increased instantly when the bear became active.

Radio-collared bears were relocated (i.e. their location was determined) using aerial telemetry from a fix-winged aircraft. Distances and direction of movements between consecutive relocations were determined using the AUTOGIS/MOSS Program (Western Energy and Land Use Team).

Home Range

Home range areas were determined using the minimum convex polygon method (Mohr 1947). Relocations were plotted with AUTOGIS/MOSS. Annual home ranges and combined home ranges were calculated. To calculate the average home range I used only those bears that were located from approximately May to October or den to den. Combined home ranges were calculated by using the minimum convex polygon method with relocations from several years.

Denning Chronology and Ecology

Den sites were located using aerial telemetry. The date of den entry was estimated by calculating the mean date between the last relocation the bear was out of the den and the first time the bear's location became stationary. Emergence dates were estimated by calculating the mean date between the last relocation the bear was in the den and the first relocation the bear was out of the den. Accuracy varied with number of days between relocations. The greater the number of days between relocations the less accurate the estimate.

Measurements of slope, aspect, and elevation were made of den sites using U.S.Geological Survey 1:63,360 topographic maps.

Population Size and Density Estimates

Population size and density estimates were not calculated. Subjective estimates were made by the IBBST from available field data collected and through interviews with long-term residents from 1984 through 1987. While caution must be taken when using these estimates, it is important to have a general idea of the population size and densities for decisions regarding management.

Observation Data

Visual brown bear observations were collected from aerial surveys, ground surveys, and sightings reported by the public. Observations were categorized as those made by the public or state and federal employees. Observations were documented on cards, and contained descriptive information which included the location, number of bears, presence of a female, and the age of any offspring (i.e. cubs, yearlings, subadults). Average litter size was estimated by using the average number of cubs, yearlings or subadults observed with a female.

Ground Surveys

Ground surveys were conducted in areas that the KNWR, ADF&G, and USFS biologists believed important to bears and areas repeatedly used by radio-collared bears. Areas were accessed by foot, boat or aircraft. We surveyed each area on foot 4 to 5 days. Areas were examined for tracks, scats and other signs of brown bear use. The size of tracks, family group size and location were used to estimate numbers of individual bears using a particular area. Open areas were surveyed for bears with binoculars and a 20 power spotting scope.

Salmon Stream Surveys

Emphasis was placed on surveying salmon spawning areas during the spawning period. The entire length of most spawning areas was surveyed on foot. Counts were made of the total number of live salmon, carcasses fed on by bears (termed bear-killed) and untouched carcasses. Tracks were used to determine if brown bears or black bears were using the area. In some cases, measuring tracks provided an indication of how many individual bears had visited the stream. Surveys where tracks were used to estimate the number of individual bears using a stream, were conducted before, during, or after the peak of the salmon run in 12%, 52% and 36% of those surveys, respectively. Some streams or rivers were surveyed more than once and provided an average number of brown bears using a particular salmon feeding site. Because the stream substrate was not always suitable to collect tracks, we also determined bear use by observing the number of bear-killed salmon or trail use along the banks of the stream. The extent that vegetation was beaten down, the condition of the trails, and the age of the sign were all noted. Individual survey summaries and maps were included in each annual report.

Habitat Evaluation Surveys

Habitat evaluation was conducted to determine what foods were available to bears in the spring. Areas were evaluated based on the presence of brown bear sign and abundance of known and suspected bear foods using a system similar to Herrero et al. (1983). The presence or absence of the most commonly used bear foods (Mace 1987), in the surveyed areas, was used to determine the general distribution of those foods on the Kenai Peninsula.

Aerial Surveys

Aerial searches for brown bears were conducted using fix-winged aircraft in portions of the KNWR and Chugach National Forest (CNF). Survey areas were selected on the basis of previous reports, by public and agency personnel, of high brown bear activity. Efforts were concentrated on alpine areas where bears could be observed soon after emerging from their dens, where suspected spring/early summer feeding activity might occur. During summer USFWS and ADF&G biologists conducted intensive aerial searches of salmon spawning areas.

Mortality Analysis

Brown Bear Mortality

Brown bear mortality data from 1961-1987 for Game Management Units (GMU) 7 and 15 (Fig. 2) were obtained from ADF&G. Mortalities consisted of bears taken in the harvest, shot in DLP or accidental deaths (i.e. capture mortalities). Mortality data were analyzed using general statistical procedures. I analyzed 27 years of mortality data in 3-year intervals. This enabled an examination of the data for any changes over time. I also grouped these data into 9-year intervals because this enabled me to isolate years during which a spring season was held and compare it to years without spring hunting.

Hunter effort for brown bears could not be determined directly because licenses were issued for statewide use. Bear hunting effort since 1966 was approximated by comparing the bear harvest with moose hunting effort. Greer (1974) suggested a similar comparison for bears and big-game species in Montana. For comparative purposes I divided

Figure 2. Game management units (GMU) on the Kenai Peninsula, Alaska, as designated by the Alaska Dept. of Fish and Game.

moose hunter numbers into 3-year intervals like mortality data.

Sex Ratio and Age Distribution of Harvested or DLP-killed Bears

Sex ratios were divided into 3-year intervals for comparisons with mortality information.

ADF&G began aging bears in 1967 so I divided the 21 years of age distribution data into 5-year intervals to examine them for changes. The earliest interval (1967-72) was actually a 6 year interval to account for the extra year. Sample size was so small in the earlier 11 years that I grouped the data into 2 larger intervals, (1 with 11 years and 1 with 10 years) to increase sample size for comparisons of adult to subadult ratios. Bears that were ≥5 years of age were considered adults while bears ≤4 were considered subadults.

Median ages of harvested males and females were calculated from 1967 through 1987. I divided these data into 5-year intervals. Median ages were used when testing hypotheses, as opposed to means, to reduce the effects of outliers. Kruskal-Wallis and One-Way Analysis of Variance tests (ANOVA) were used for multi-sample comparisons (Conover 1980, Dowdy and Wearden 1983).

DLP deaths were tested for trends using Jonckheere's test for ordered alternatives (Hollander and Wolfe 1973).

Allowable Human-Caused Mortality

Observation data were used to calculate a natality rate for Kenai bears. Natality rate was defined as average litter size (1.81, estimated from observations) divided by the average breeding interval (3.4, estimated). Bunnell and Tait (1980,1981) developed a model based on the relationship between natality rate and age of first parturition to determine sustained mortality rates for a population. Plotting these variables (natality rate = 0.53, first parturition = 5) into their model provided an estimate of approximately 12% as the maximum mortality rate, from all causes, the peninsula population could withstand.

An estimate of population size had not been made using mark-recapture techniques, however, USFWS and ADF&G biologist's best estimates ranged from 150 to 250 bears. Using these figures three scenarios were created for analyzing the maximum mortality rate by using estimated natural mortality rates (Harris 1984, Bunnell and Tait 1985), reported mortality rate (i.e. harvest and DLP), and unreported rates (Brannon et al. 1988). By subtracting estimated natural mortalities from the total mortalities the population could withstand, I estimated the number of allowable human-caused mortalities for the peninsula.

RCR Trail Survey

A system to monitor human use and human/bear encounters on the RCR trail system was installed for 3 years. We placed electronic trail counters at 4 locations and installed visitor questionnaire signs containing maps and observation cards at all 3 trailheads within the system (Fig. 3).

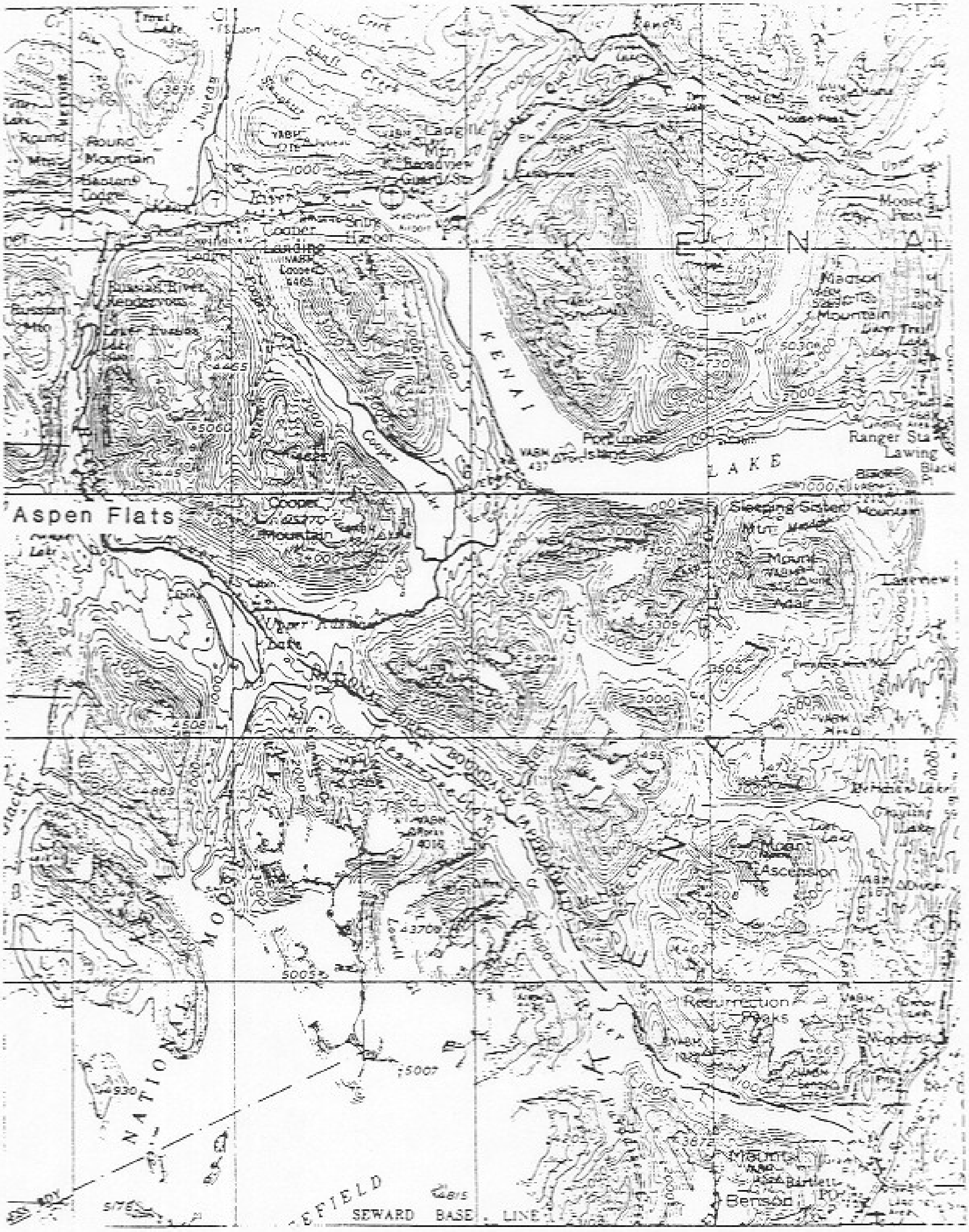


Figure 3. The Russian River/ Cooper Lake/ Resurrection River trail system located on the Kenai Peninsula, Alaska.

RESULTS

Field Work Summary

In 1984 the IBBST completed a review of the currently available scientific literature pertaining to brown bear feeding habits (Risdahl 1984). Individuals were interviewed, either local biologists or long-time residents of the peninsula, to investigate historic and current areas used by bears. Twenty-two aerial surveys were conducted between May and October. Habitat evaluation surveys were conducted in 4 areas suspected to be important brown bear habitat. Ground surveys of 23 streams containing significant salmon spawning areas were conducted. A system was initiated to monitor human use and human/bear encounters on the RCR trail system. Two bears were captured and radio-collared by helicopter darting. They were relocated 25 times by aerial telemetry. A synopsis of the data collected in the 1984 field season was published in the IBBST 1984 Annual Report (Bevins et al. 1985).

In 1985 the study team surveyed 10 streams in 5 new areas and 3 areas that had been previously surveyed. Eleven aerial surveys were conducted in June and July. Monitoring of human use and human/bear encounters on the RCR trail system was continued. Four bears were successfully radio-collared and relocated 63 times by aerial telemetry. Den sites for 3 of these bears were located. A synopsis of the data collected in the 1985 field season was published in the IBBST 1985 Annual Report (Risdahl et al. 1986).

In 1986 ground surveys were conducted to assess food presence and abundance in 2 areas where collared bears were relocated. Surveys were also conducted in 2 areas surveyed in previous field seasons in order to compare bear use on a seasonal basis. Five salmon streams were surveyed to determine the extent of use by bears during salmon runs. Two areas were investigated to select potential snaring sites. Two bears were successfully snared and radio-collared. Four bears, 2 collared in 1985 and 2 collared in 1986, were relocated 103 times in 1986. The user survey on the RCR trail system was also conducted. A synopsis of the data collected in the 1986 field season was published in the IBBST 1986 Annual Report (Schloeder et al. 1987).

In 1987 four bears, 2 collared in 1985 and 2 collared 1986, were relocated 56 times. Two dens were located during aerial telemetry. Trail counters were not installed on the RCR trail system but the questionnaire survey was conducted. A synopsis of the data collected in the 1987 field season was published in the IBBST 1987 Annual Report (Jacobs et al. 1988).

In 1988, field data collected from the previous 4 years of research and the harvest data from 1961 through 1987 were compiled and analyzed.

Tagging Efforts and Telemetry Data

Fifteen adult brown bears were captured and tagged from 1984 through 1987 (Table 1). Eight of 15 bears (5 females and 3 males) were fitted with radio collars. An additional 4 adult bears (2 females, 2 males) were captured in 1978 as part of a moose calf mortality study (Table 1). Radio relocations from these 4 bears were used to supplement our data set for estimating home range size.

Relocations

To determine movement patterns and habitat selection daily relocations during both day and night would be necessary. Relocations were not consistent enough for this analysis. Although relocation data were limited, and did not allow us to test a hypothesis concerning habitat use versus availability, it seemed that bears were highly dependent on salmon spawning areas during the summer. Of 100 relocations between 1 July and 1 October from 1984-1987, 73% were located on or very near salmon streams.

Home Range

Some individual bears provided more than one annual home range estimation if they were relocated for several years (Table 2). The number of relocations used to estimate annual home range sizes ranged from 7 to 31. Annual male

Table 1. Capture data and fate of brown bears captured on the Kenai Peninsula, Alaska, 1978-1987.

	capture				comments / fate of bear
Sex/ID#	age	type	date	location	
MA01 *	12.5	h	5/78	Bear Lake	10/80 harvested 8 km NW of Portage Lake
FA02	7.5	h	5/78	Owl Lake	in estrous / unknown
MA03	7.5	h	6/78	Grus Lake	unknown
FA04	3.5	h	6/78	Grus Lake	in estrous / unknown
F001	5.5	h	8/84	Funny River	lone female slipped collar
M002 *	2.5	h	8/84	Killey River	5/86 harvested near Silver Lake
M003	8.5	h	9/84	Upper Funny R.	male slipped collar
M004	8.5	h	4/85	South Bay Lakes	unknown
F005	14.5	h	6/85	Tustumena Glacier	had 3 young / signal stopped
F006	5.5	h	6/85	East of Russ. River	capture mort.
F007	7.5	h	6/85	Suprise Mountain	had 1 cub / still transmitting
M008	3.5	h	7/85	Funny River	unknown
F009	14.5	h	7/85	Funny River	had 3 yearlings / unknown
M010 *	5.5	h	7/85	Upper Funny R.	10/86 harvested Skilak Glacier Flats
F011	1.5	s	7/86	Goat Creek	unknown
M012 *	24.5	s	8/86	Goat Creek	6/87 harvested Funny R. horse trail
F013	6.5	s	9/86	Upp. Russian Lake	had 1 cub / still transmitting
M014	4.5	s	9/86	Upp. Russian Lake	capture mort.
M015	2.5	s	7/87	Goat Creek	unknown

type of capture
h=helicopter darted
s=snared

* Tagged bears in the harvest

Table 2. Summary of home range estimates for all brown bears radio collared on the Kenai Peninsula, Alaska, 1978-1987. Combined home range estimates were calculated using two or more years of relocations.

Sex/ID#	year	no. days collared	annual home range km^2		combined home range km^2
F001	1984	111	438		
M003	1984	35	162		
M004	1985	772	852	*	1275
	1986		738	*	
	1987		420		
F005	1985	434	186	*	376
	1986		215		
F007	1985	1083	527	*	823
	1986		250	*	
	1987		155	*	
F009	1985	80	363		
M012	1986	279	918	*	948
	1987		43		
F013	1986	638	21		38
	1987		25	*	
MA01	1978	45	524		
FA02	1978	50	241		
MA03	1978	255	1290	*	
FA04	1978	152	1264	*	

* approximately den emergence to den entrance estimates

ranges averaged 949.6 km^2 (n=4, range = 738.2-1290.4, SE=7.73) while annual female home ranges averaged 401.2 km^2 (n=6, range = 24.8-1264.3, SE=8.69). Combined home range estimates based on all locations for bears with more than one year of data averaged 1111.5 km^2 (n=2) for males and 412.3 km^2 (n=3) for females. Home range maps for collared bears are located in Appendix A.

Denning Chronology and Ecology

Usually males entered dens from late October through November and emerged in early April. One male bear emerged on or before 31 March. Females entered dens from late October, one denned 18 November, and emerged approximately mid-April. Average dates of entrance/emergence for males and females were 12 November/5 April and 6 November/20 April, respectively (Table 3). Average number of days in the den for males was 144 (n=2, SE=2.3) and 168 for females (n=5, SE=1.3).

Ten den sites were located at a mean elevation of 546 m (range = 152m - 1296m, SE=5.77) and a mean slope of 19.8° (range = 15° - 27°, SE=0.69) (Table 4, Fig. 4). The mean den slopes for males and females were 19.5° and 20° respectively. Average elevation of den sites was higher for females (650 m, n=6) than males (389 m, n=4) but was not significant (Student's t: P = 0.12). Only one bear, an adult male, denned on the Kenai Lowlands. All others denned

Table 3. Den enterence and emergence dates for brown bears on the Kenai Peninsula, Alaska , 1984-1987.

Sex/ID	mean date entered den	(accuracy)	mean date emerged den	(accuracy)
M004	11/23/85	(8 days)	4/06/86	(10 days)
M004	11/02/86	(21 days)	3/31/87 *	
M012			4/11/87	(04 days)
F005	11/11/85	(13 days)	4/08/86	(15 days)
F007	11/15/85	(06 days)	4/29/86 *	
F007	11/06/86	(12 days)	4/28/87	(13 days)
F007	10/26/87	(13 days)	4/22/88 *	
F013	11/06/86	(12 days)	4/28/87	(13 days)
F013			5/01/88	(18 days)

* Date that bear was first located out of the den.

Table 4. Den ecology for brown bear den sites located in 1978 and from 1984-1987 on the Kenai Peninsula, Alaska.

Sex/ID no.	year	elevation(m)	slope	aspect(TN)
M004	1985	152	17°	183°
	1986	201	17°	245°
M012	1987	396	17°	36°
MA03	1978	808	27°	96°
F005	1985	442	15°	312°
F007	1985	396	27°	277°
	1986	732	21°	206°
	1987	1296	25°	76°
F013	1986	503	15°	96°
	1987	533	17°	92°

TN = true north

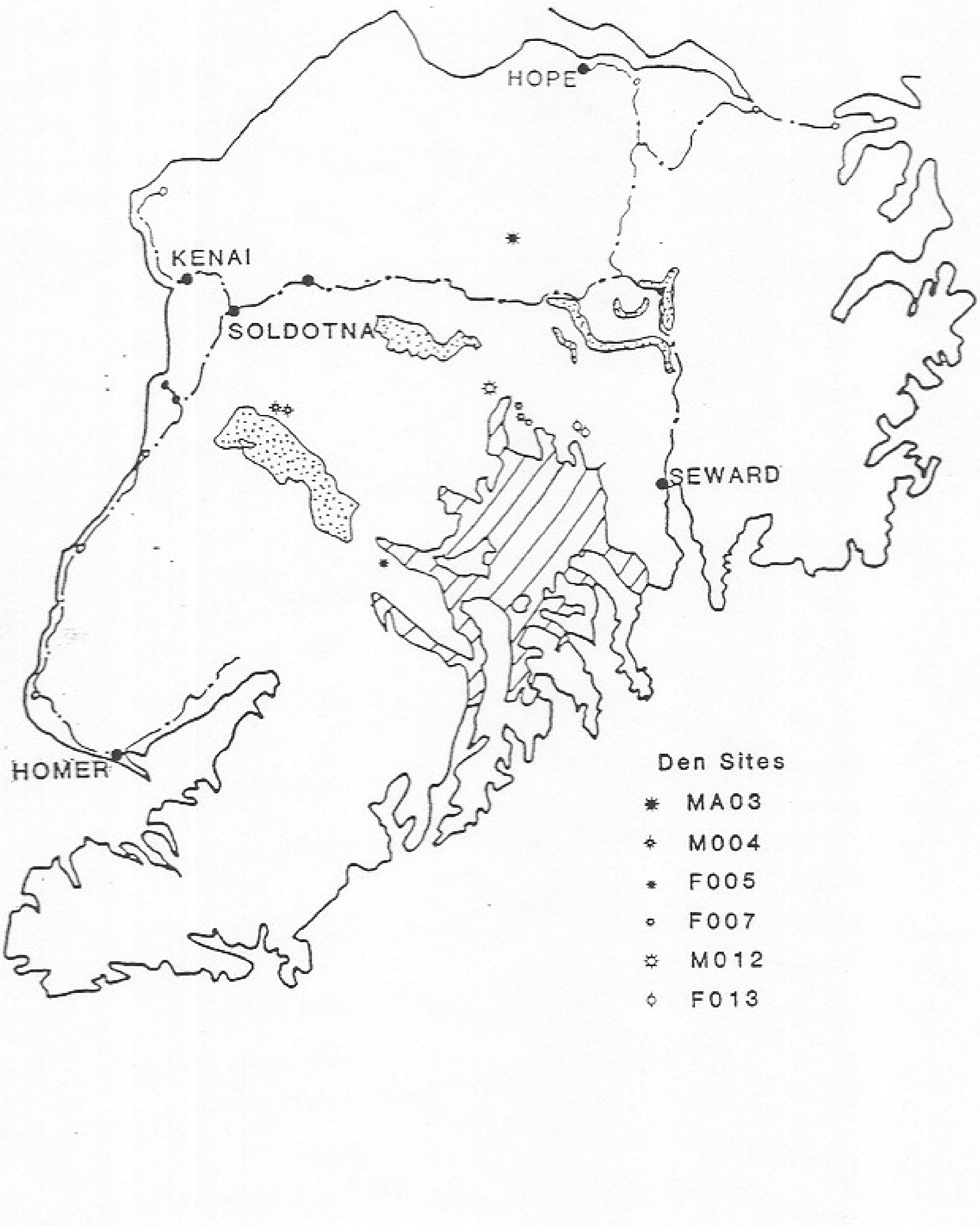


Figure 4. Ten den locations of collared brown bears located by aerial telemetry on the Kenai Peninsula, Alaska.

in the mountains on steep hillsides.

Population Size and Density Estimates

With the data collected by the IBBST, population size and density estimates were not possible to calculate. USFWS and ADF&G biologists speculate there were between 150 to 250 brown bears. Applying this population size to the areas on the peninsula that bears used most (Bevins et al. 1985, Risdahl et al. 1986, Schloeder et al. 1987, Jacobs et al. 1988), gave an approximate density of 1 bear/35-59 km^2. The area this estimate was applicable to was 8800 km^2.

Observation data

A total of 170 sightings (i.e. the number of instances a bear was seen) were reported, involving 283 bears, from 1984-1987 (Fig. 5) (Appendix B). There were no significant differences in the cub:female, yearling:female or subadult:female ratios when comparing public sighting to state/federal employee sightings (Anova: $P < 0.05$), therefore results were pooled. Of all sightings 35.6% (n=101) were single bears, 11.6% (n=33) were pairs (i.e. assumed not a female with offspring), 33.9% (n=96) were either cubs, yearlings or subadults and 18.7% (n=53) were females. Females with offspring included 8.8% (n=25) with cubs, 5.3% (n=15) with yearlings and 4.6% (n=13) with subadults (Table 5).

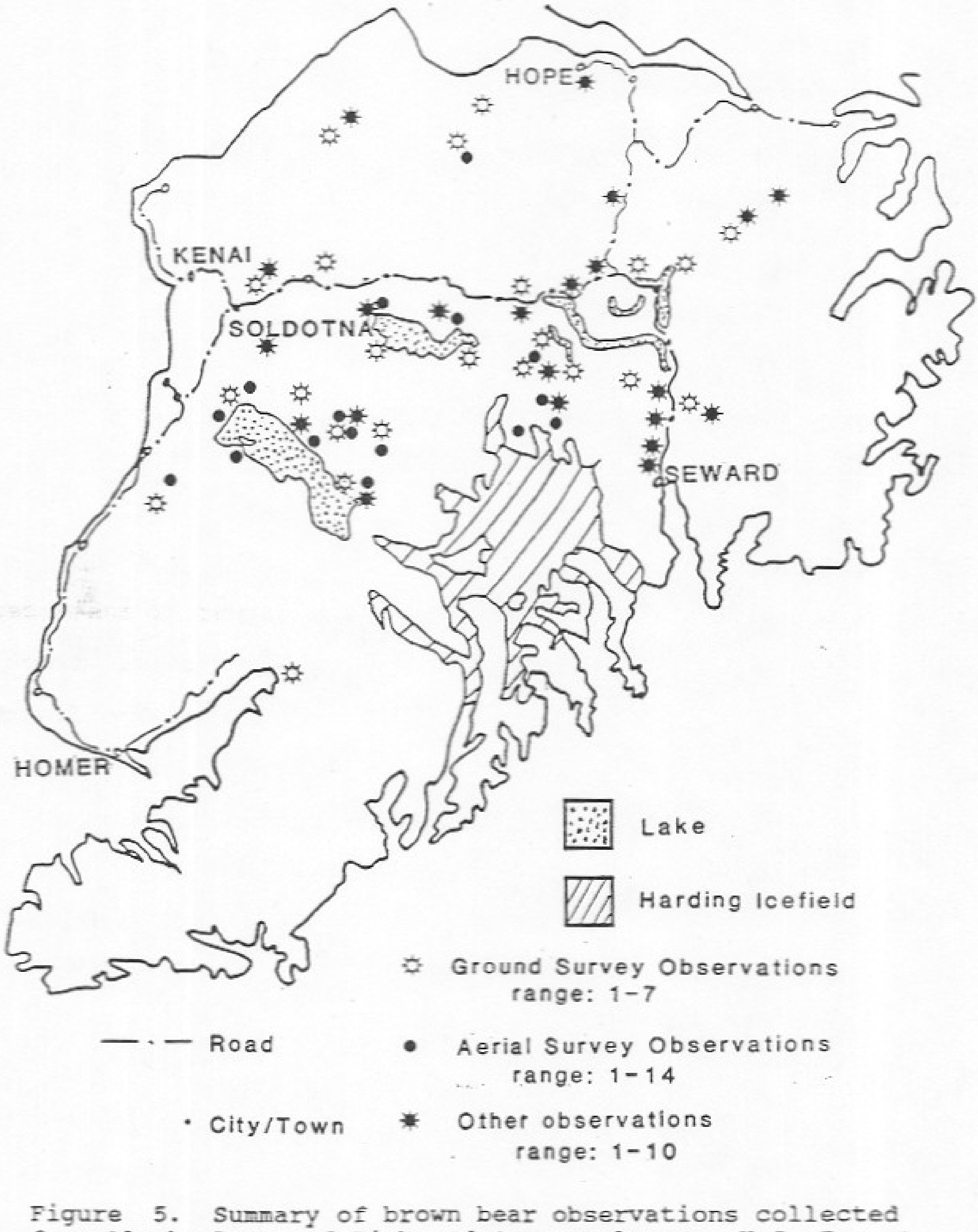


Figure 5. Summary of brown bear observations collected from Alaska Dept. of Fish and Game employees, U.S. Forest Service employees, U.S. Fish and Wildlife employees and the public from 1984 through 1987.

Table 5. Brown bear observation data collected on the Kenai Peninsula, Alaska, 1984-1987. All observation types are combined (i.e. public and state/federal employee sightings).

YEARS	no. single bears	no. females W/(CUBS)	no. females W/(YEARL)	no. females W/(SUBADULT)[1]	no. pairs
1984-87	101	25(42)	15(28)	13(26)	15 + 1 *

Average number of cubs per female =1.68 (n=25)

Average number of yearl. per female =1.87 (n=15)

Average number of subs per female =2.0 (n=13)

[1] subadults include 2.5 and 3.5 year old cubs
* this was a group of 3 bears

Average litter size was 1.7 for females with cubs, 1.9 with yearlings, and 2.0 with subadults. The weighted average litter size when all age classes were combined was 1.8 young per female.

Ground Surveys

Salmon Stream Surveys

Thirty-eight salmon stream surveys on 31 different streams were conducted along portions (i.e. 1 km to 20 km in length) of streams where salmon spawn. Based on track counts, average bear use was estimated on 25 salmon streams to be 2.6 bears/stream (range= 0 to 11, SE=0.56). Salmon stream surveys provided information about the location of areas where bears fed on salmon and the number of bears using a stream at any given time. Heavy use areas were those with ≥6 bears. When 4 years of track data was combined the total number of individual bear tracks counted was 84. Of the areas adequately surveyed, the highest bear use was in the benchlands between Skilak Lake and Tustumena Lake.

Habitat Evaluation Surveys

The staple foods present in the spring were grasses, sedges, and horsetail (Bevins et al. 1984, Risdahl et al. 1986, Schloeder et al. 1987). In spring these foods were first available in avalanche chutes and wet areas and were abundant and widely distributed across the peninsula. They occurred in all of the 12 habitat surveys conducted. When available, winter/wolf-killed moose and caribou were observed to be favored foods in the spring. Two radio-collared bears were observed to travel >17 km to the same caribou carcasses. Bangs et al.(In Press) reported that 1% of the annual mortality in adult female moose was caused by brown bears.

Aerial Surveys

Thirty one aerial surveys were flown from April to October during 1984 and 1985 totaling 87.3 hours of flight time. Since aerial surveys were usually flown over refuge lands, information could only be applied to those areas. A mean of 1.3 bears/hour of flight time was observed, with the highest ratio of bears/hour observed in July (Table 6). Because aerial surveys were not flown on a grid pattern we could not use them to estimate population size or density.

Mortality Data

Brown Bear Mortality

A total of 245 known mortalities occurred from 1961 to 1987 (males=120, females=118, 7=unknown). Mortalities were of three types; harvest (n=192), DLP (n=51) and accidental (n=2)(Table 7).

Table 6. The rate of brown bear observations during aerial surveys on the Kenai Peninsula, Alaska, 1984-1985. Radio-collared bears were included.

Month	no. of surveys	bears/hour
April	1	0.50
June	6	1.60
July	10	1.99
August	7	1.16
Sept.	4	0.08
Oct.	3	0.74

Table 7. Known brown bear mortalities on the Kenai Peninsula, Alaska, 1961-1987.

Sources Mortality	males	females	undetermined	total
Sport harvest	99	90	3	192
DLP *	20	27	4	51
accidents	1	1	0	2
total	120	118	7	245

overall sex ratio for mortalities
50.4 % males
49.6 % females

* Defense of life or property (DLP)

Brown bear mortalities increased over the last 27 years (Fig. 6). An average of 6.4 bears per year were reported killed from 1961-1969, 7.5 bears per year from 1970-1978 and 13.2 bears per year from 1979-1987. From 1979-1987, total mortalities had increased significantly from the previous 18 years (1961-1969, 1970-1978)(ANOVA: $P = 0.001$). Harvested bears had also significantly increased in the past 9 years (ANOVA: $P = 0.001$). When bears harvested in the fall were tested among 9 year intervals, again the number taken in the last 9 years was significantly greater (ANOVA: $P = 0.004$) than the previous 18 years.

The average number of brown bear mortalities had nearly doubled from 1970-1978 to 1979-1987. I tested the assumption that an increase in the number of moose hunters resulted in an increase in the brown bear harvest. The two hunting seasons had overlapped completely or in part since 1966. During the last 22 years, 79% of the bears harvested were taken during the moose season. There was not a close correlation between moose hunters and harvest of bears in GMU 7, 15A, or 15B (GMU 7: $r=0.09$, GMU 15A: $r=0.28$, GMU 15B: $r=0.15$) (Figs. 7,8,9). However, a significant correlation was found between moose hunter effort and brown bear harvest in GMU 15C (Spearmans: $r = 0.49$, $\alpha = .1$) (Fig. 10).

A spring brown bear season has been in effect since 1978 and 1980 in GMU 15 and GMU 7, respectively. The

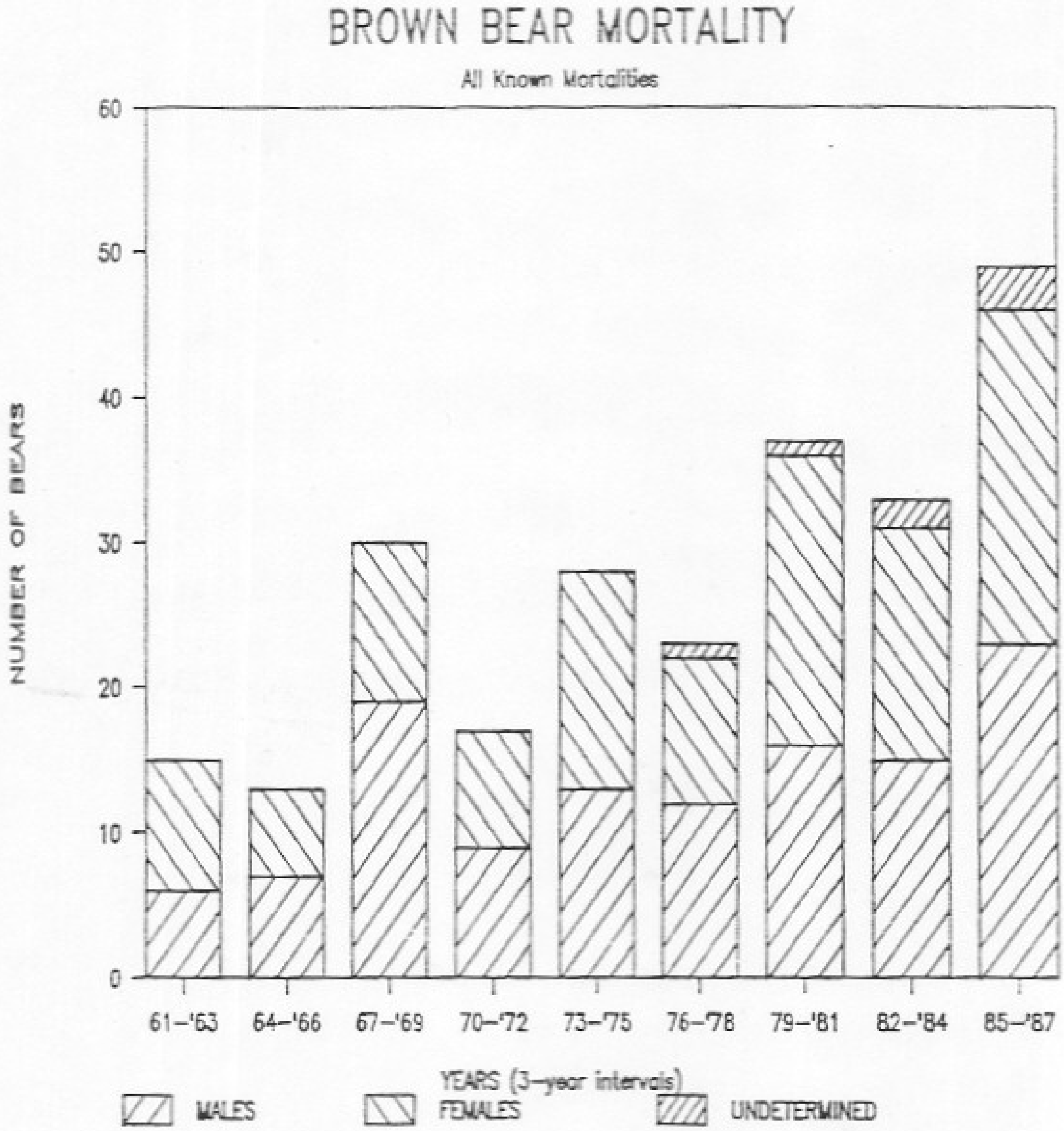


Figure 6. Brown bear mortalities on the Kenai Peninsula, Alaska, 1961-1987. Some mortalities were not sexed, thus classified as undetermined.

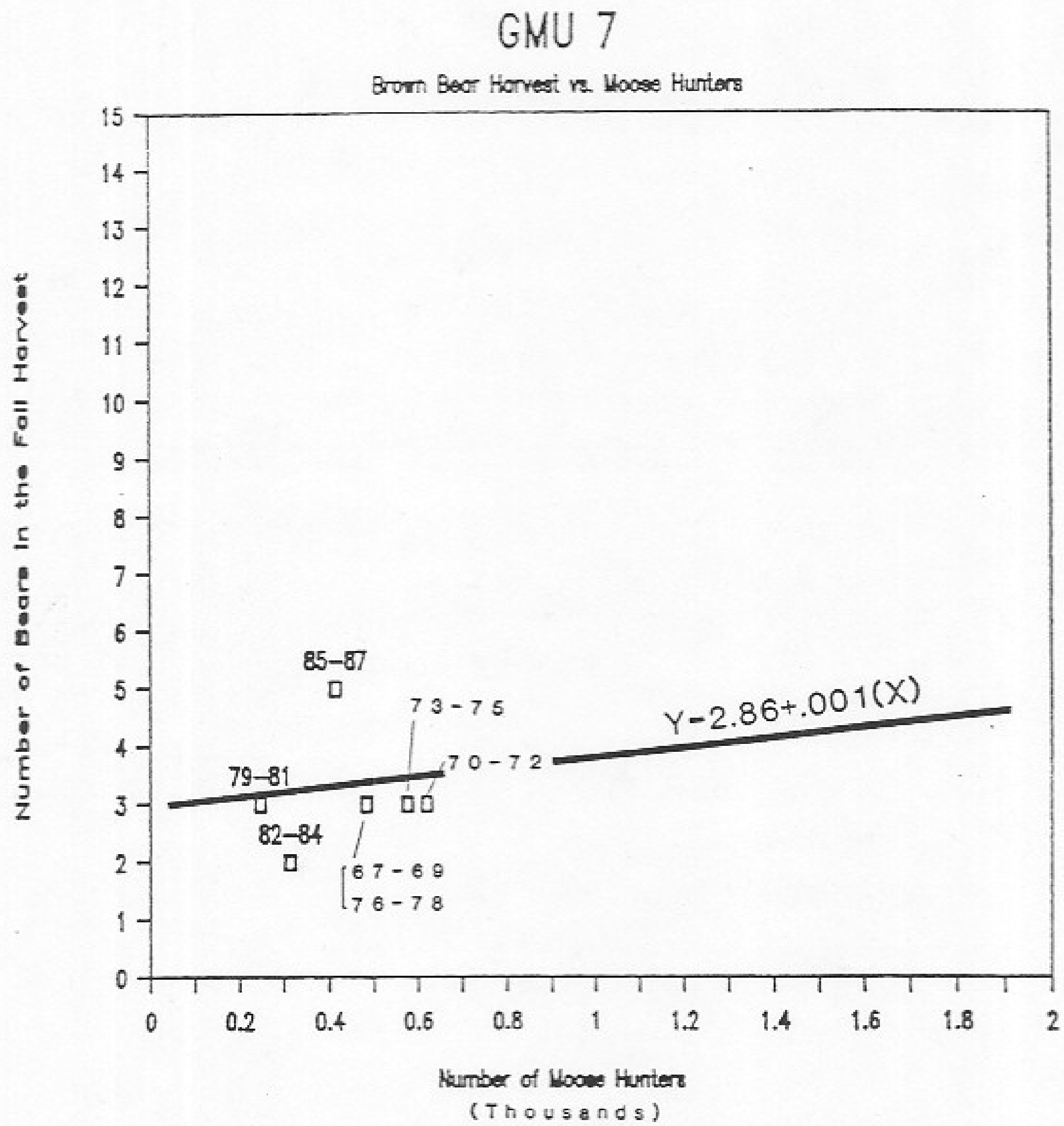


Figure 7. The relationship between the number of brown bears in the harvest and the number of moose hunters in game management unit (GMU) 7, from 1961 through 1987.

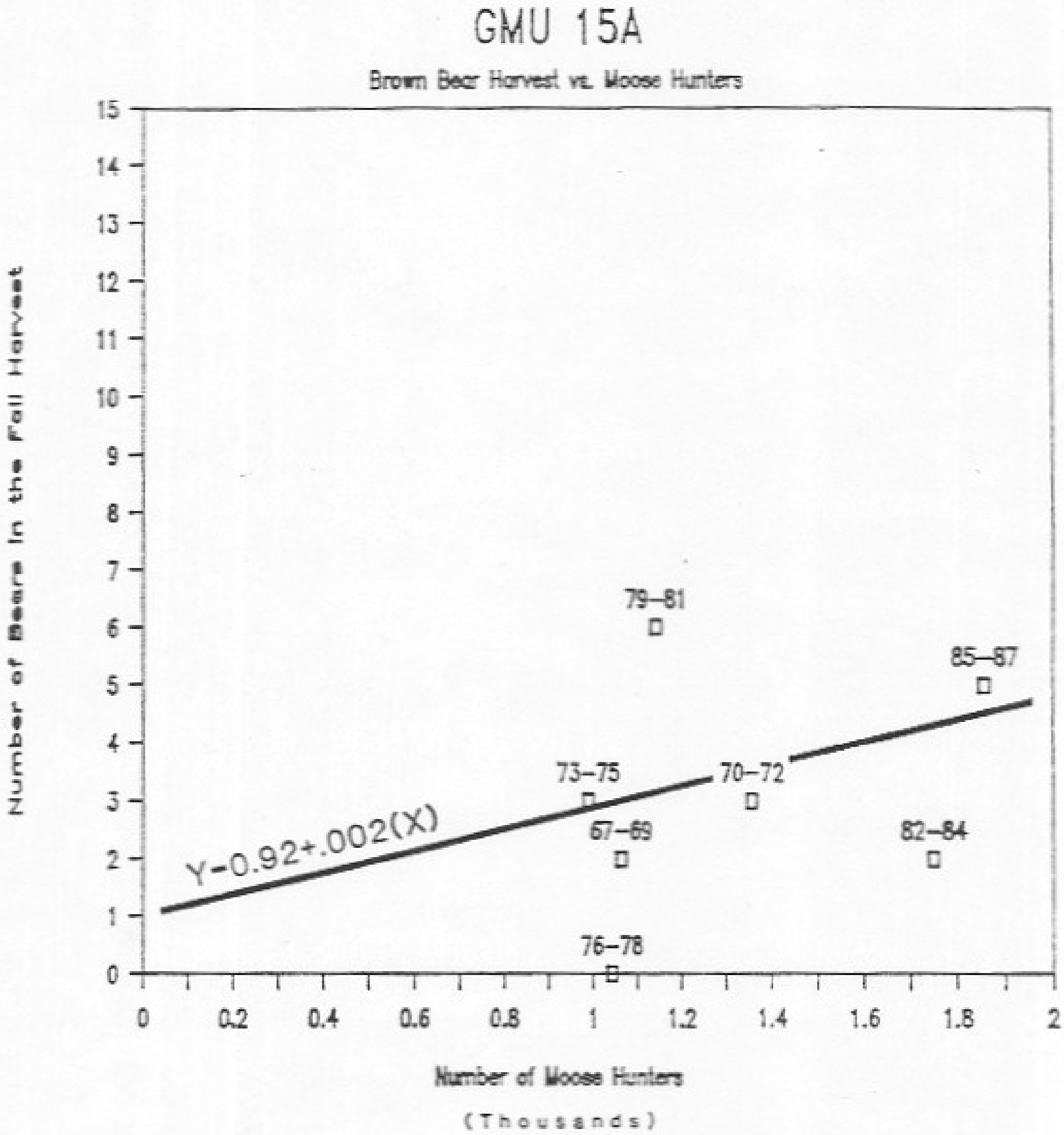


Figure 8. The relationship between the number of brown bears in the harvest and the number of moose hunters in game management unit (GMU) 15A, from 1961 through 1987.

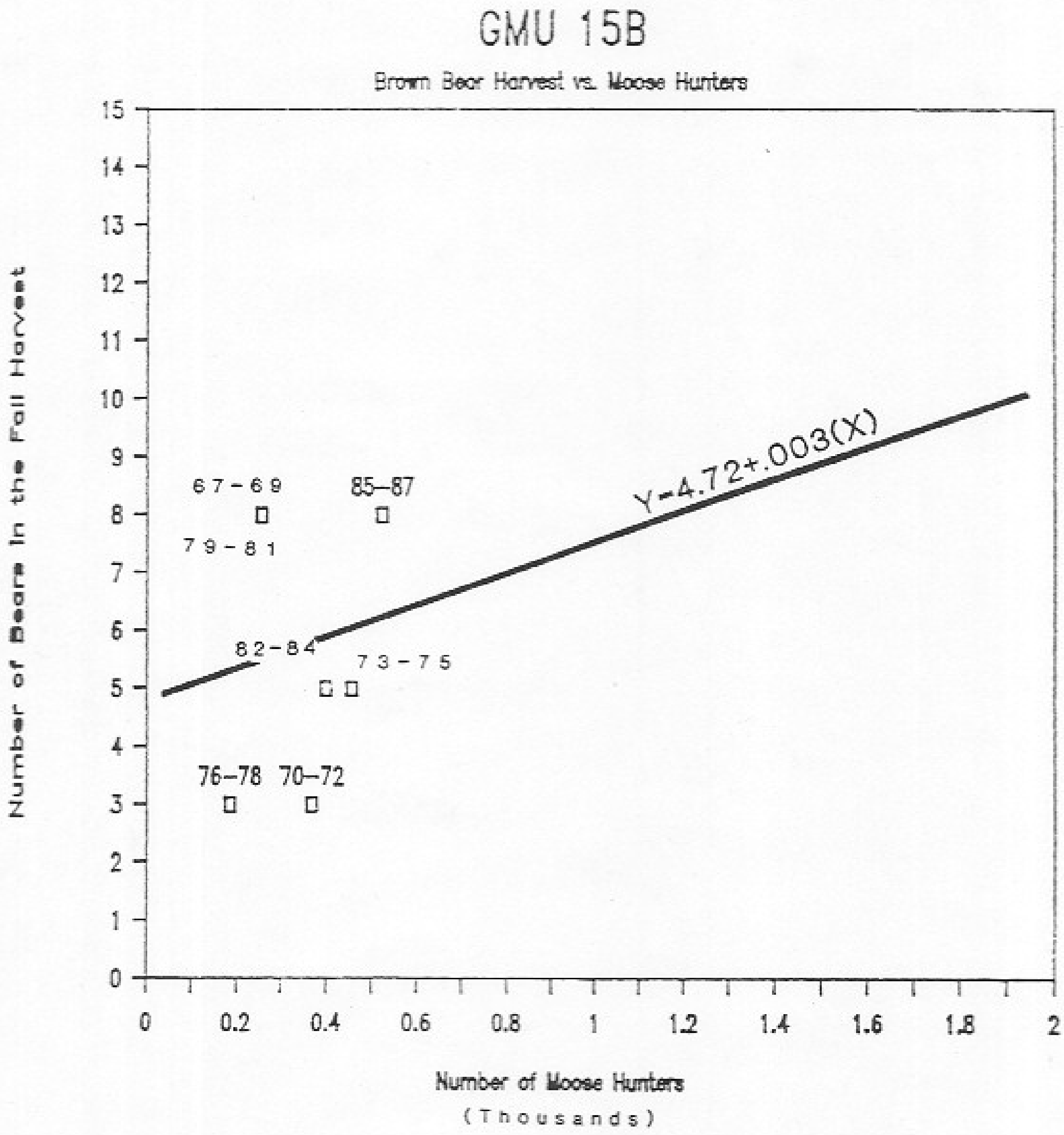


Figure 9. The relationship between the number of brown bears in the harvest and the number of moose hunters in game management unit (GMU) 15B, from 1961 through 1987.

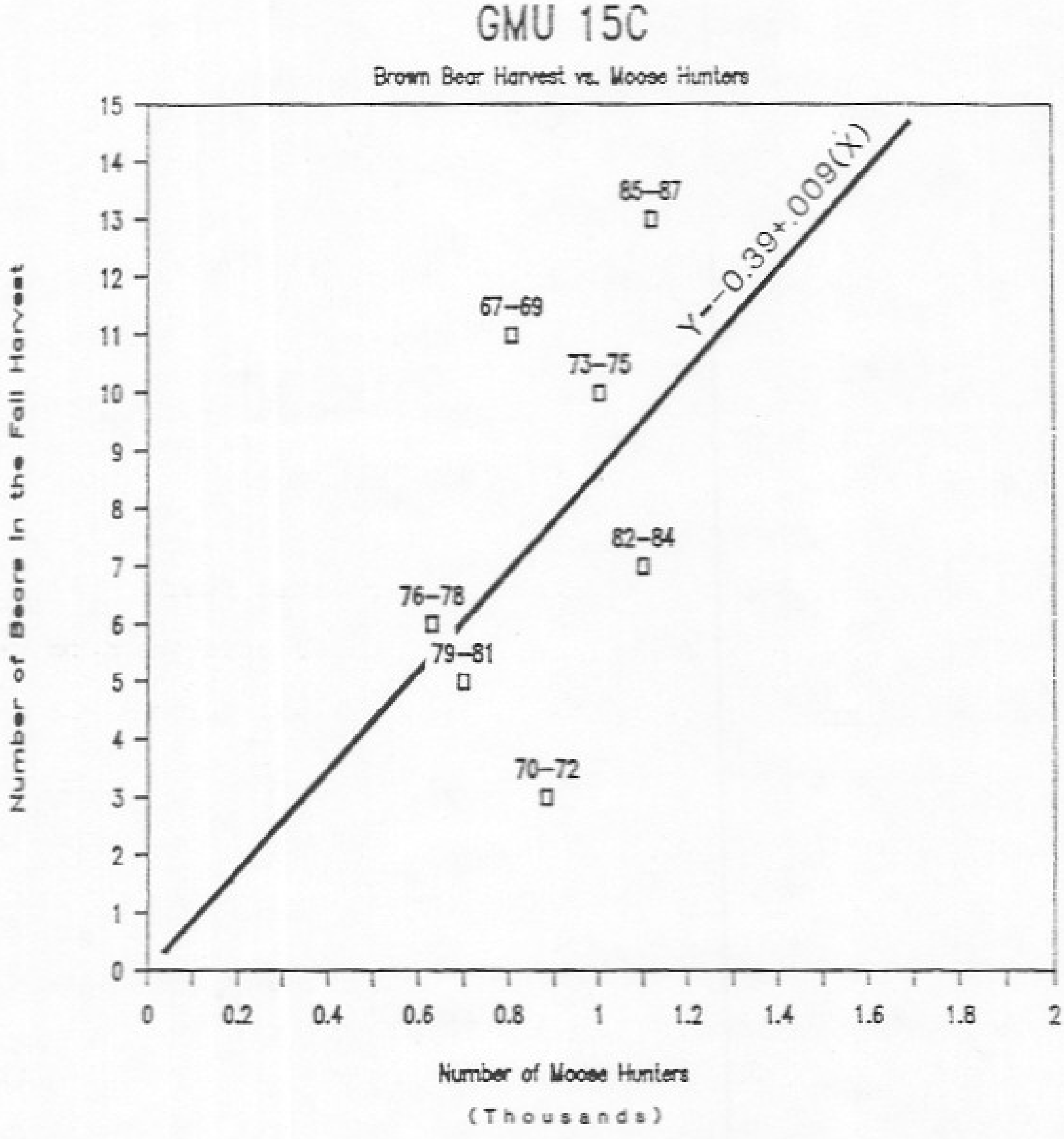


Figure 10. The relationship between the number of brown bears in the harvest and the number of moose hunters in game management unit (GMU) 15C, from 1961 through 1987.

spring season increased the overall number of hunting days per year from about 30 days (1961-76), to 52 days (1978-83). Yearly season length was increased to 61 days, starting in 1984. The increased season length seemed to increase bear mortalities accordingly (Fig. 11).

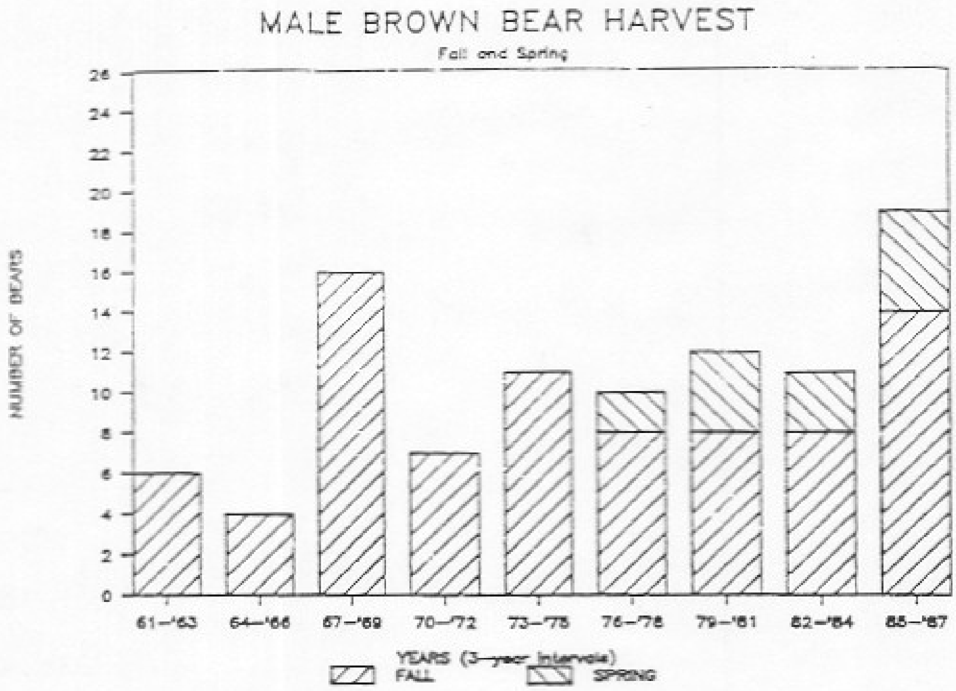
Mortalities were not distributed evenly across the peninsula. West of the Kenai Mountains (GMU 15) 203 bears were shot, while only 42 bears were shot east of the mountains (GMU 7). Sixty five percent were killed in game management units 15B and 15C, but mortalities increased in all units from 1961 through 1987 (Table 8).

Sex Ratio and Age Distribution of Harvested Bears

Sex ratios in the harvest had varied from year to year (Fig. 12) but averaged 1:1, (males:females) for all 27 years combined. From 1961 through 1987, 52% males (n=99) and 48% females (n=90) were harvested. When grouped in 9 year intervals sex ratios were 1.2:1 (n=48 for 1961-69), 1.5:1 (n=48 for 1970-78) and 0.9:1 (n=93 for 1979-87).

Spring harvest (1978-87) was 61.5% male (n=16) and 38.5% female (n=10), while the sex ratio of the fall harvest over the same time period was 44.5% males (n=32) and 55.5% females (n=40).

Age distribution of harvested bears ranged from 1.5 to 28.5 years for males and 1.5 to 17.5 years for females (Fig.13). The harvest of males from 1967 through 1987



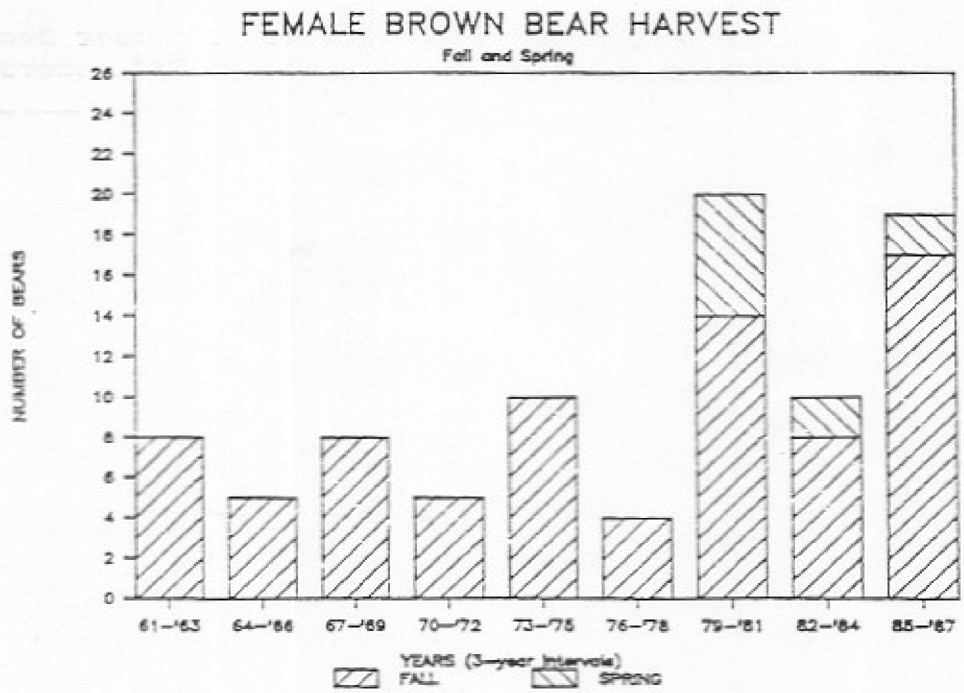


Figure 11. Summary of brown bears in the spring or fall harvest from 1961 through 1987 on the Kenai Peninsula, Alaska.

Table 8. Reported brown bear mortalities among game management units on the Kenai Peninsula, Alaska, 1961-1987.

GMU	1961-69	1970-78	1979-87	Total	male:female*
7	8	15	19	42	19:21
15A	11	13	24	48	27:20
15B	14	18	33	64	27:34
15C	24	23	43	90	46:42
morts./year (all units)	6.3	7.6	13.2		

* male:female ratios do not equal the total number because some bears were not sexed. One bear had no GMU recorded.

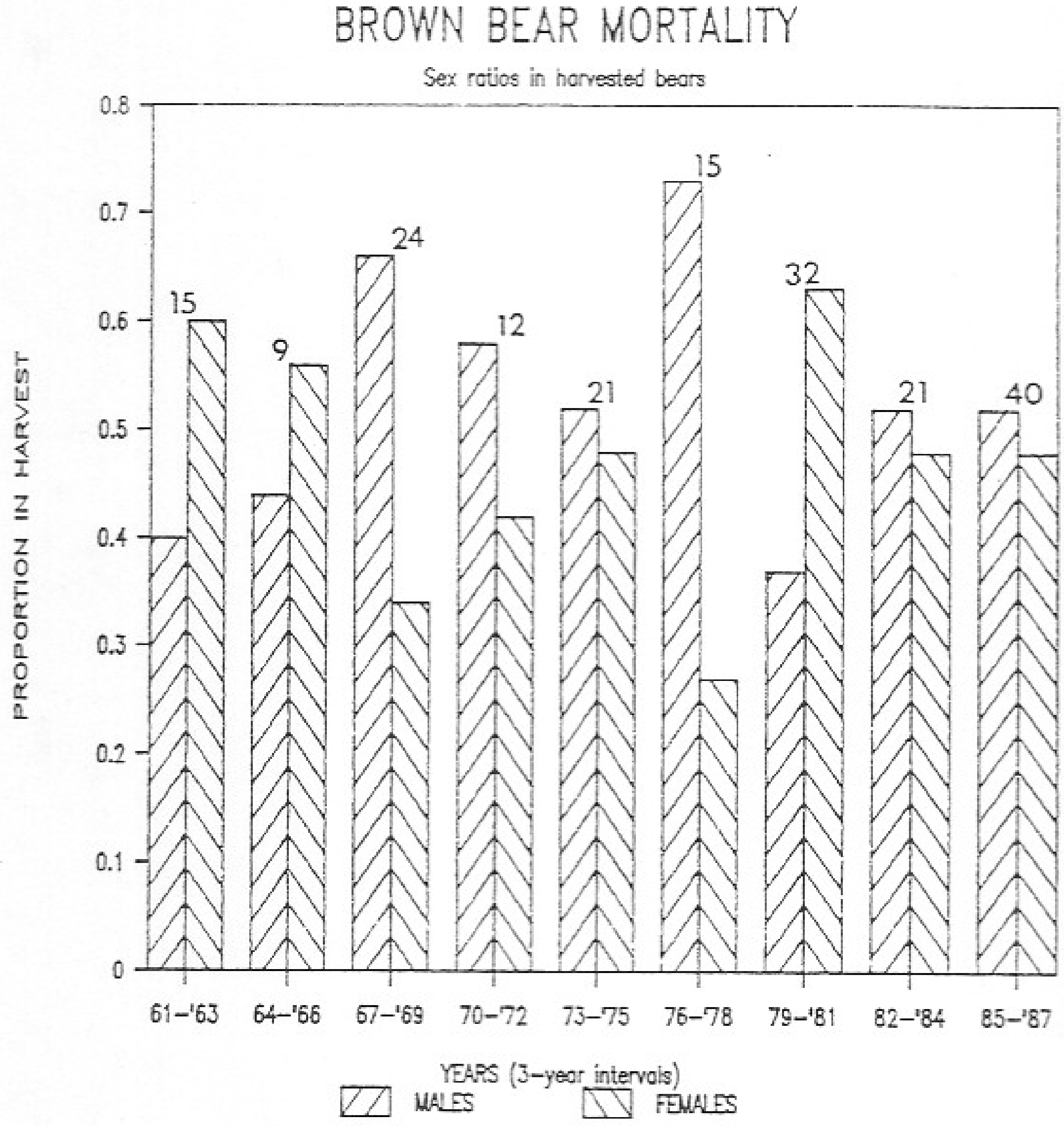


Figure 12. Sex Ratio in the harvest from 1961-87 on the Kenai Peninsula, Alaska. Sample sizes are located above each pair of bars.

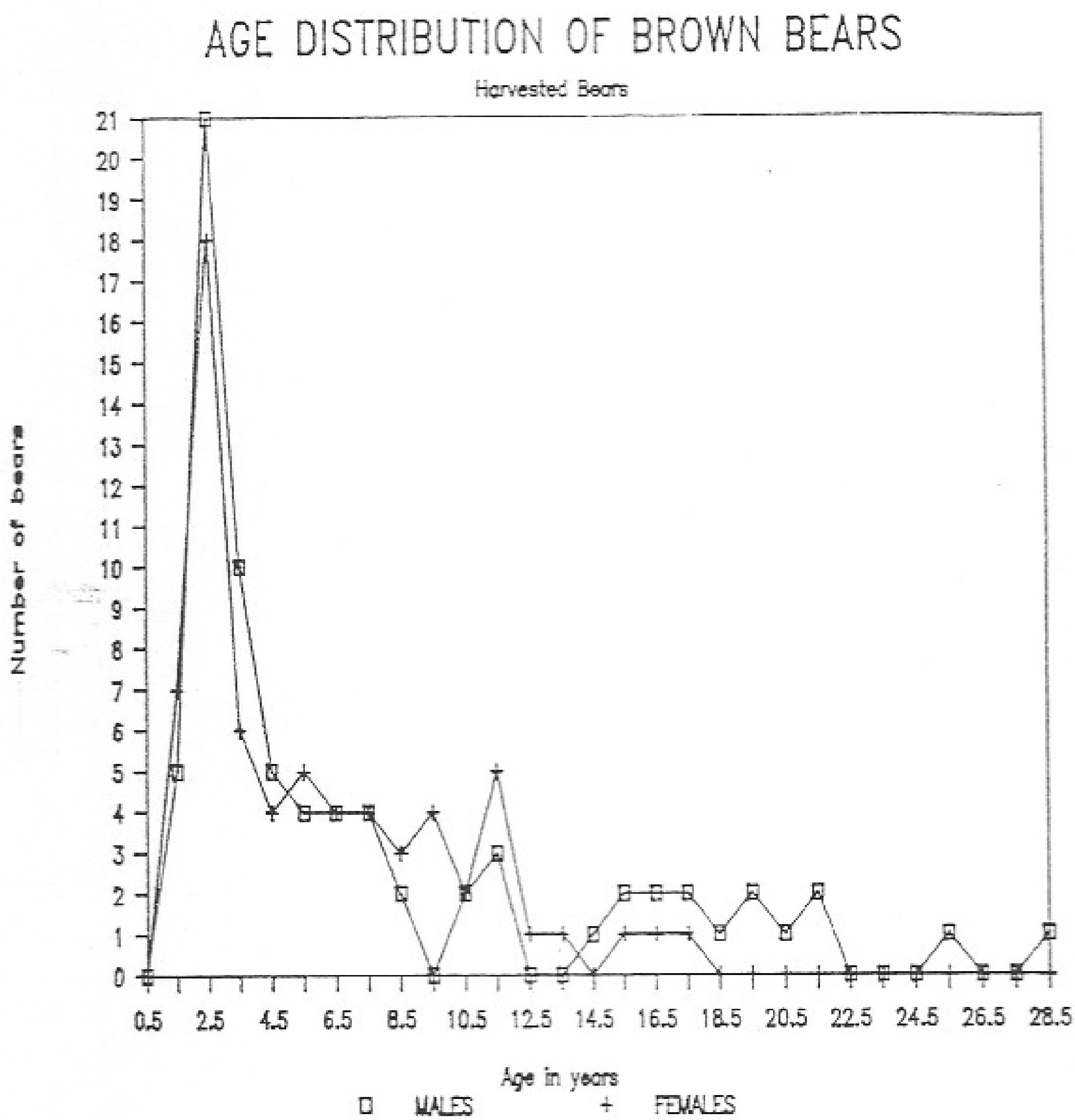


Figure 13. Age distribution in the harvest for males and females on the Kenai Peninsula, Alaska, 1967-87.

consisted of 45.4% adults (n=34), and 54.6% subadults (n=41). The harvest of females for the same period consisted of 47.8% adults (n=32) and 52.2% subadults (n=35).

All of the oldest bears were males. There were 8 males older than 17.5 years, which was the age of the oldest female taken in the harvest.

Age distributions among the harvest, when divided into 5-year intervals, did not reveal any trends. Adult to subadult ratios fluctuated over the intervals (Table 9, Figs. 14, 15, 16, 17). Grouped in 10-year intervals the age distribution, during 1967-77, of the male harvest was 36.7% adults and 63.3% subadults (n=30) while female harvest was 50% adults and 50% subadults (n=22). From 1978-87 the age distribution of the male harvest was 53.4% adults and 46.6% subadults (n=45) while the female harvest was 46.7% adults and 53.3% subadults (n=45).

The median age of harvested males from 1967 through 1987 was 4.5 (n=75) while the age class most frequently seen in the harvest was 2.5 (28%, n=21). The median age of harvested females was 4.5 (n=67) while the age class most frequently seen was 2.5 (27%, n=18).

From 1967 through 1987 there was no significant evidence of a difference in median ages, between 5-year intervals, for either males (Kruskal-Wallis: P =0.27) or females (Kruskal-Wallis: P =0.48) (Fig.18). Median ages differed among GMU's. GMU 15C had the lowest median ages

Table 9. Proportions of subadults (≤4) and adults (≥5) taken in the brown bear harvest on the Kenai Peninsula, Alaska, 1967-1987.

	Males			Females		
Years	subadult	adult	(n)	subadult	adult	(n)
1967-72	57.1%	42.9%	(14)	55.5%	44.5%	(9)
1973-77	68.7%	31.3%	(16)	46.1%	53.9%	(13)
1978-82	42.8%	57.2%	(21)	63.6%	36.4%	(22)
1983-87	54.1%	45.9%	(24)	43.4%	56.6%	(23)

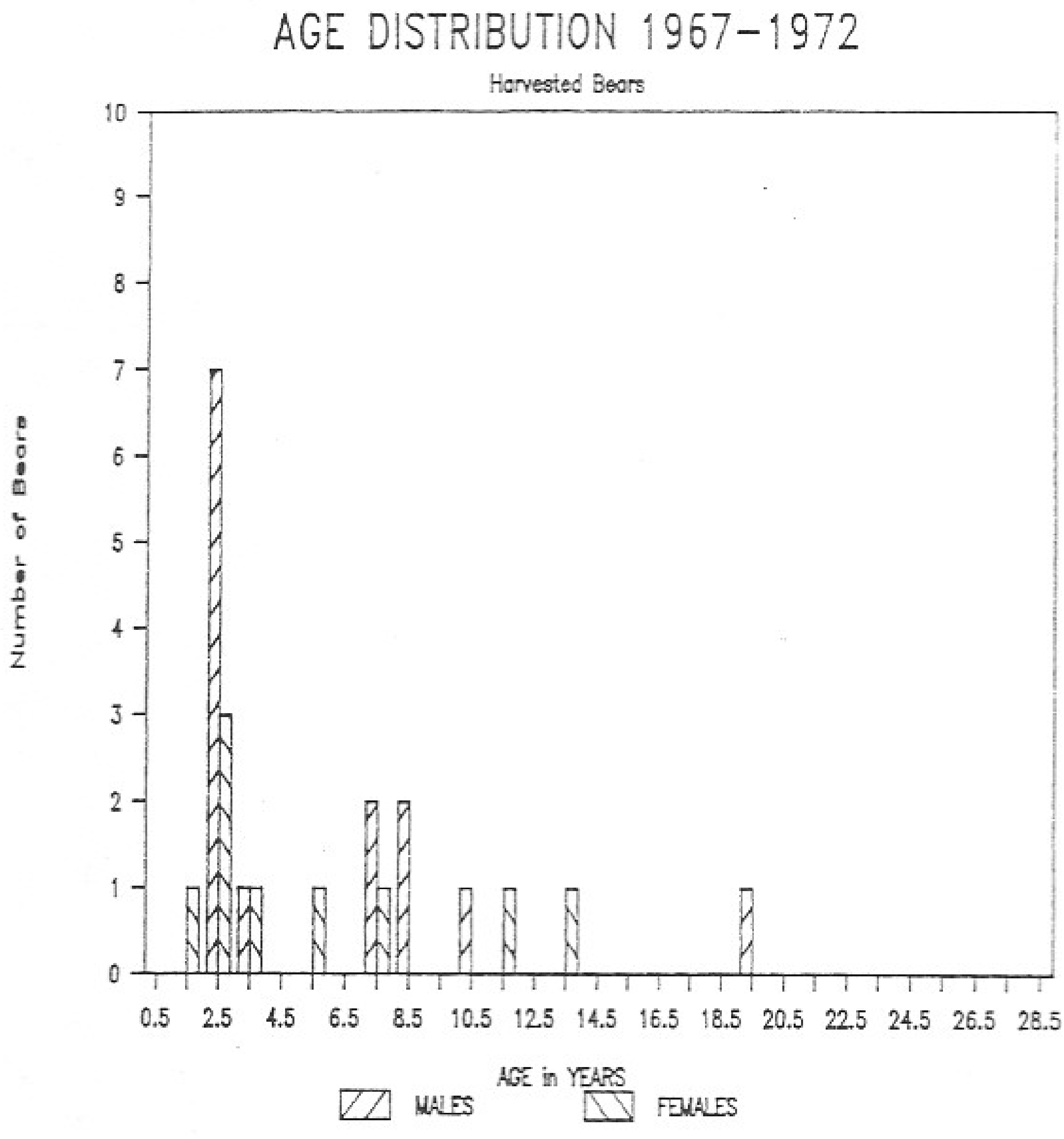


Figure 14. Age distribution in the harvest for male and female brown bears on the Kenai Peninsula, Alaska, 1967-1972.

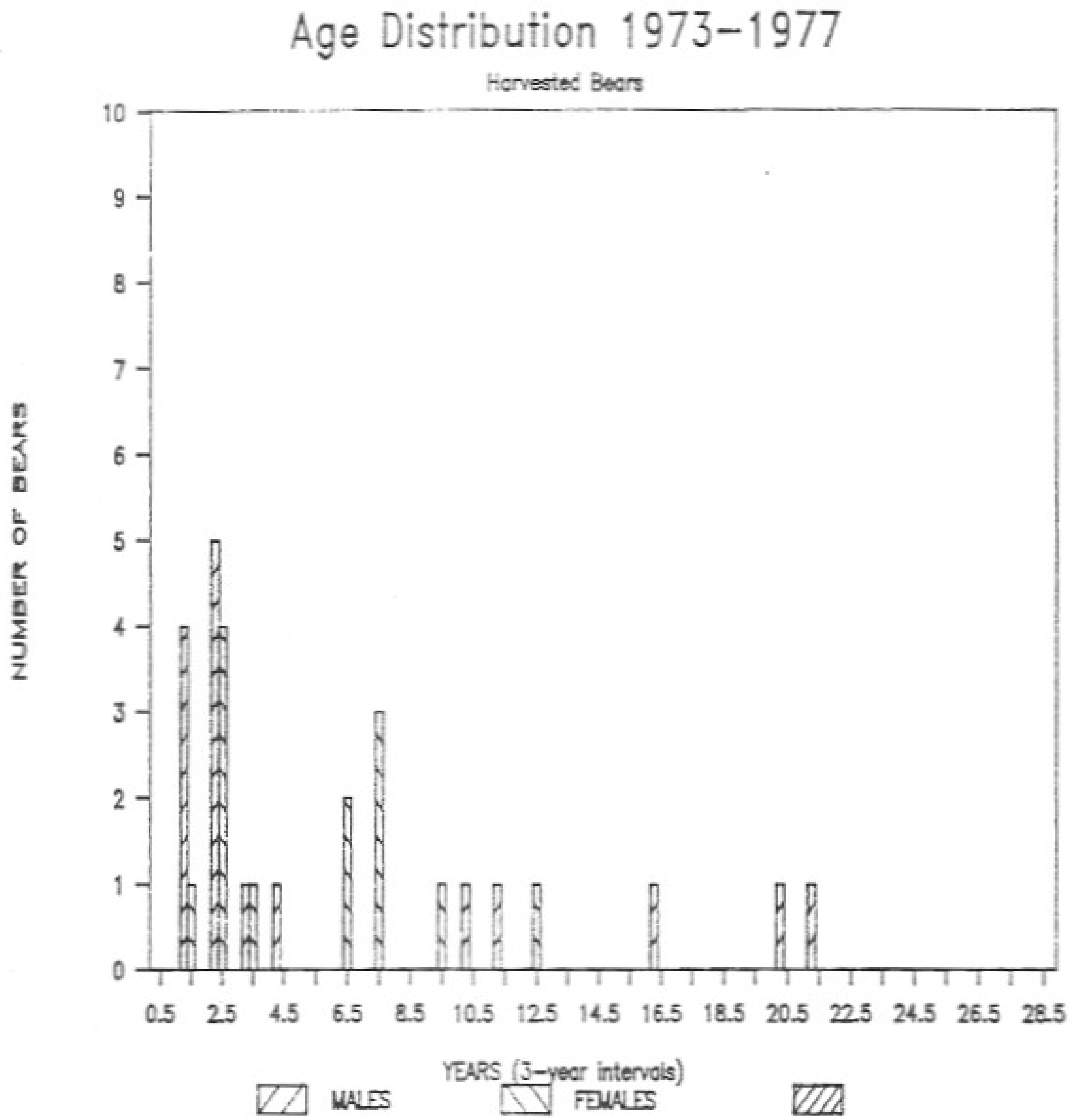


Figure 15. Age distribution in the harvest for male and female brown bears on the Kenai Peninsula, Alaska, 1973-1977.

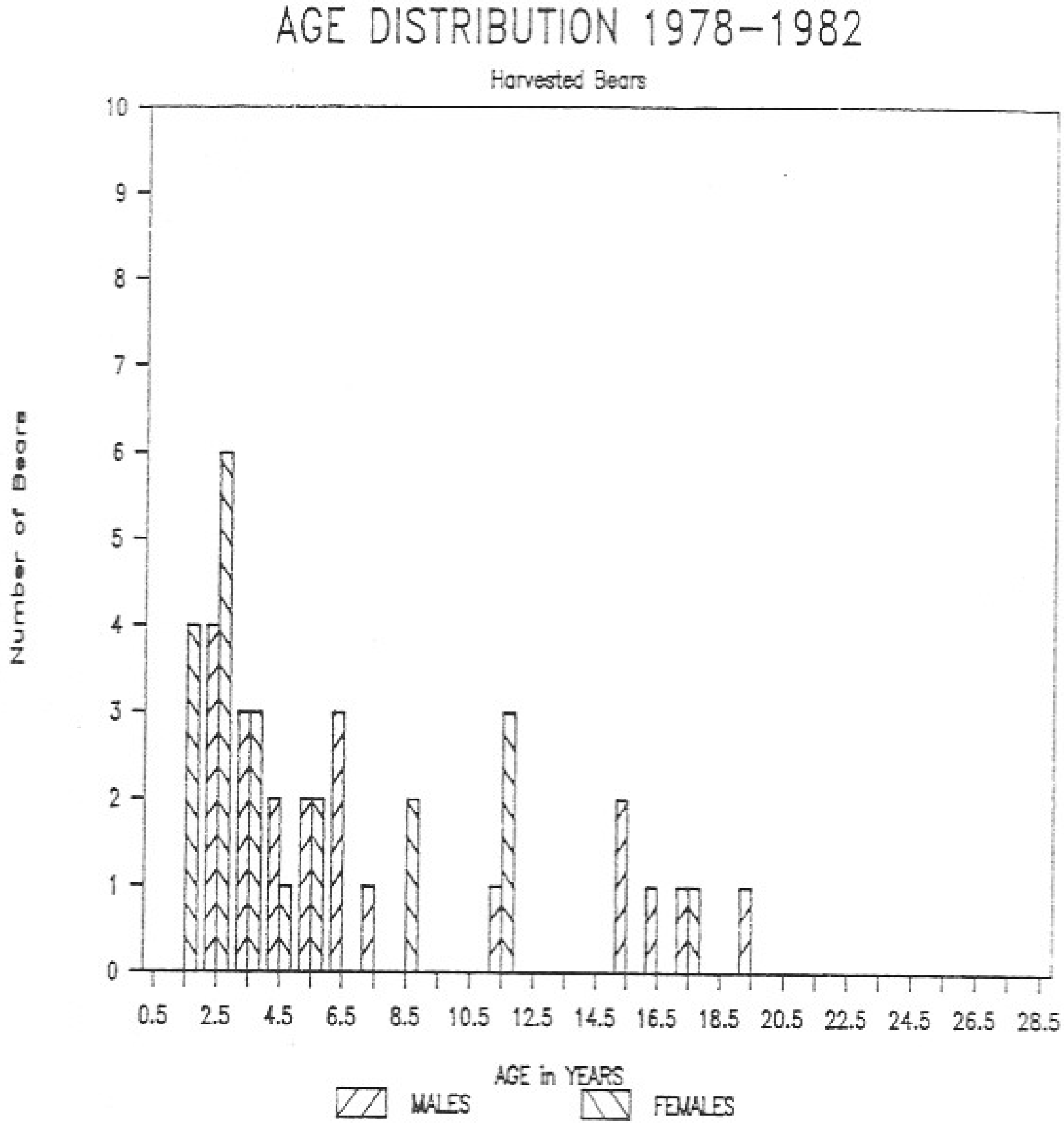


Figure 16. Age distribution in the harvest for male and female brown bears on the Kenai Peninsula, Alaska, 1978-1982.

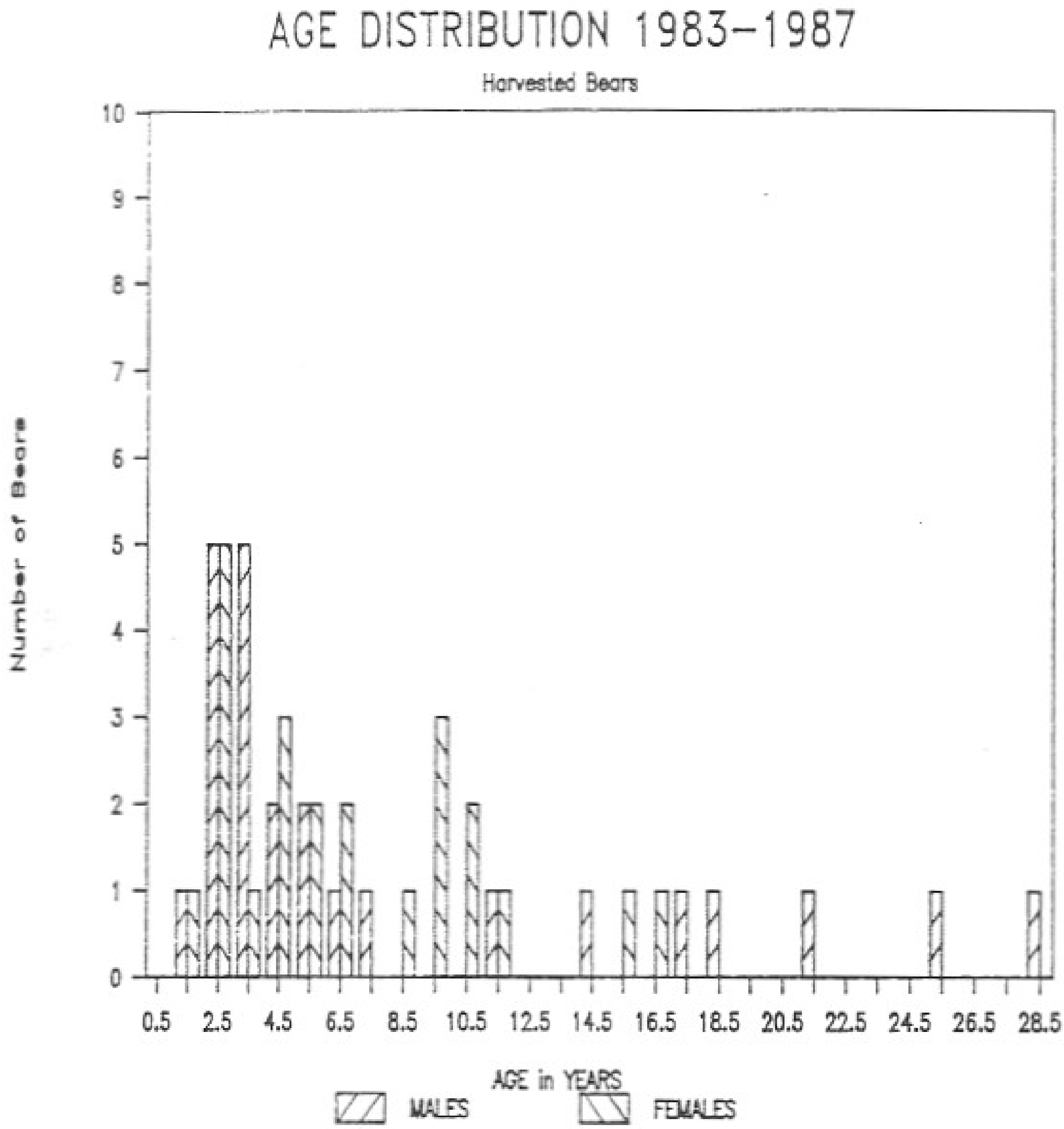


Figure 17. Age distribution in the harvest for male and female brown bears on the Kenai Peninsula, Alaska, 1983-1987.

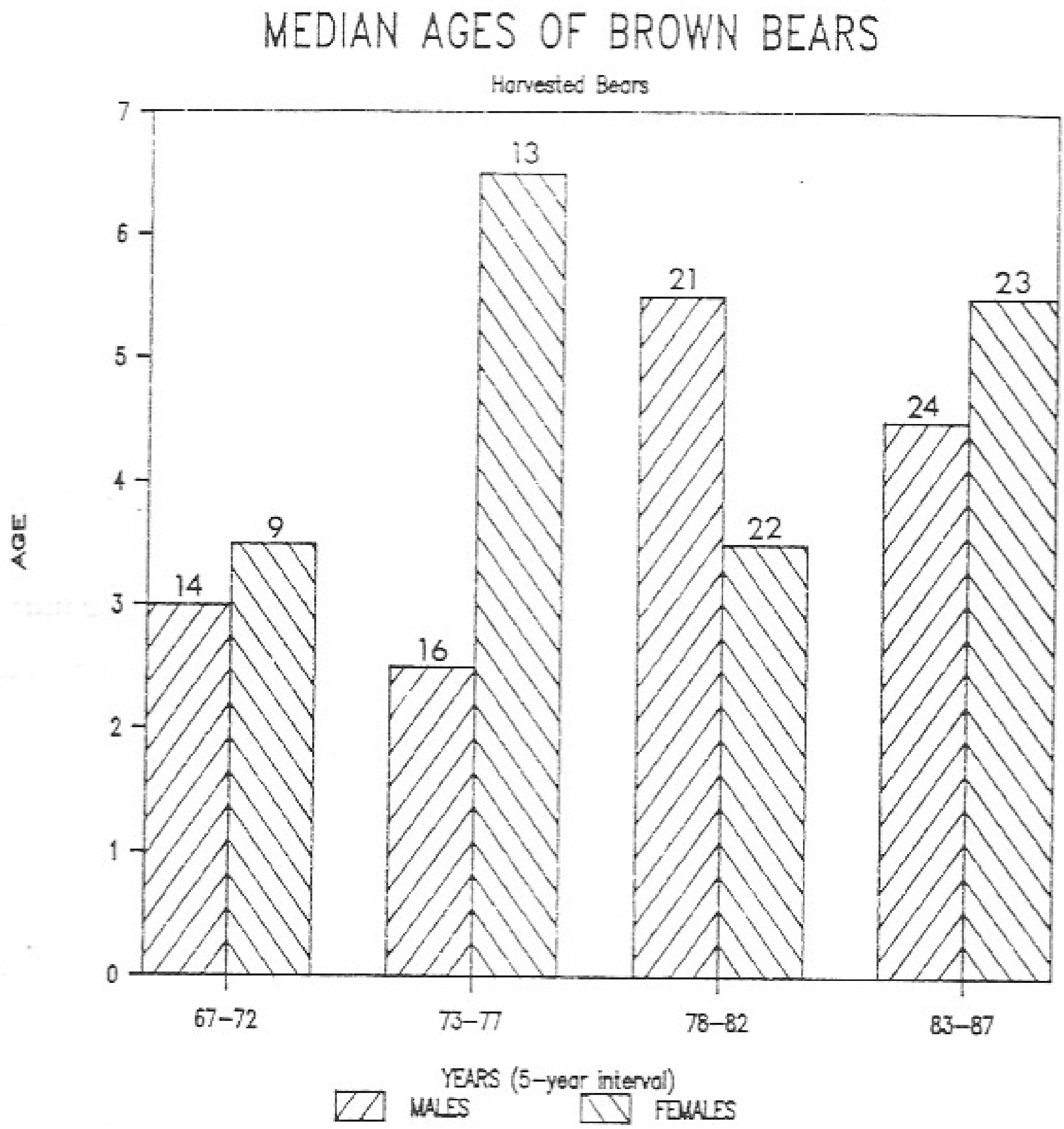


Figure 18. Median ages in the harvest of male and female brown bears on the Kenai Peninsula, Alaska, 1967-1987. Sample sizes are located above each bar.

for both male and female bears (Fig. 19). However, the sample sizes were to small to test for significant differences.

Sex Ratio and Age Distribution of DLP Bears

The sex ratio for bears killed in DLP conflicts was 0.9:1, males to females. Bears killed in DLP conflicts accounted for 23% (n=20) and 16.7% (n=27) of all mortalities for males and females, respectively. Although DLP deaths accounted for a large proportion of the total mortalities recorded there was no evidence of a significantly increasing number of bears killed under this classification (Jonckheere: P =0.12) (Fig. 20). DLP deaths occurred from April through November and were most common in late spring and early fall (Fig. 21). Since 1966, only 11 of 46 DLP's occurred during the moose hunting season.

Age distribution for males ranged from 0.5 to 25.5 years while females ranged from 2.5 to 13.5 years (Fig. 22). Males killed in DLP conflicts consisted of 40% adults (n=6) and 60% subadults (n=9). Females killed in DLP conflicts consisted of 66.6% adults (n=12) and 33.3% subadults (n=6). The median age for DLP males was 3.5 (n=15); the age class most frequently seen was 1.5 (27%, n=4). Median age for DLP females was 6.5 (n=18); the age class most frequently seen was 2.5 (22%, n=4).

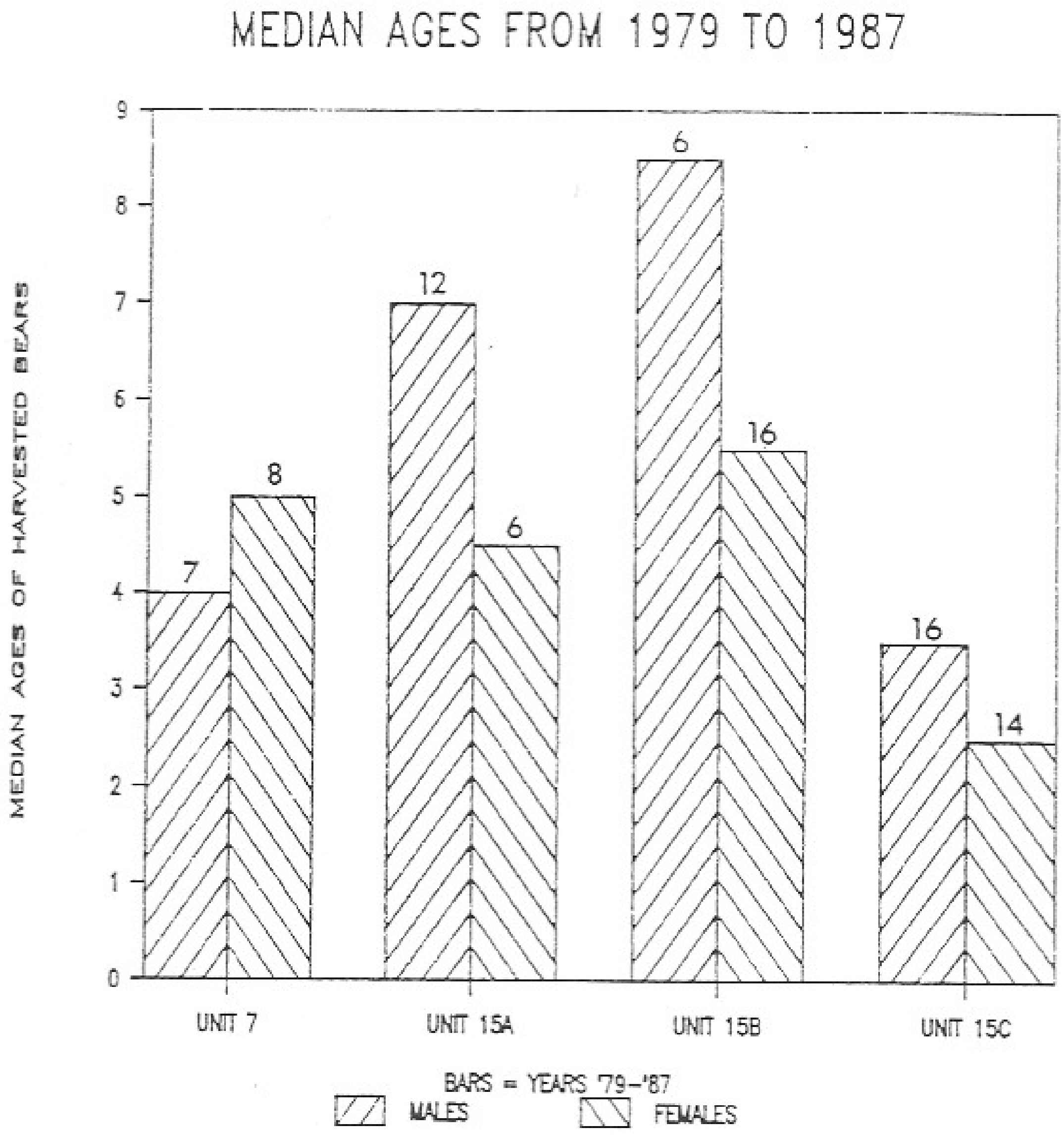


Figure 19. Median ages in the harvest with regard to game management units on the Kenai Peninsula, Alaska, 1979-1987. Sample sizes are located above each bar.

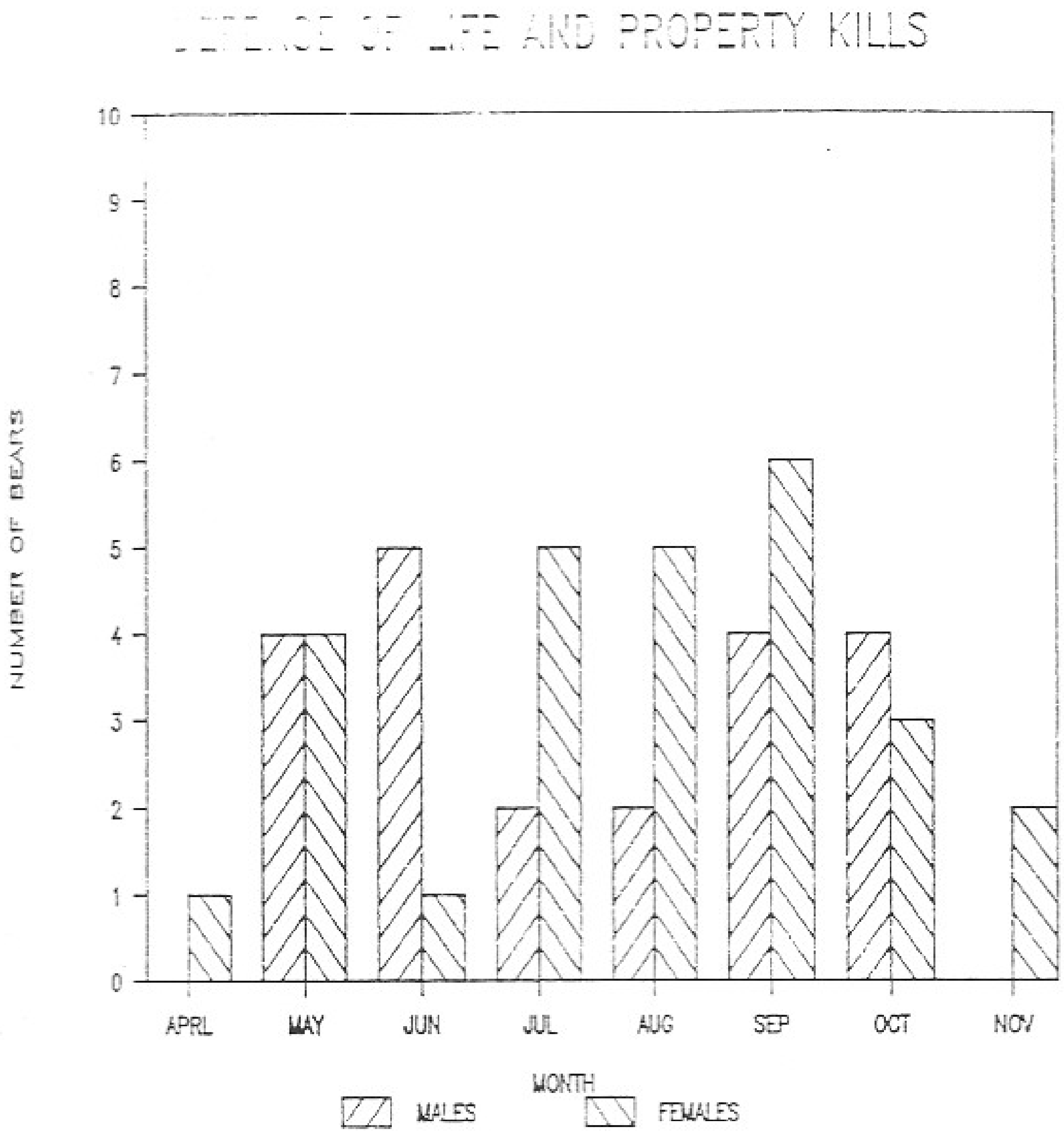


Figure 21. Summary of the months in which brown bears were killed in defense of life or property (DLP) on the Kenai Peninsula, Alaska, 1961-1987.

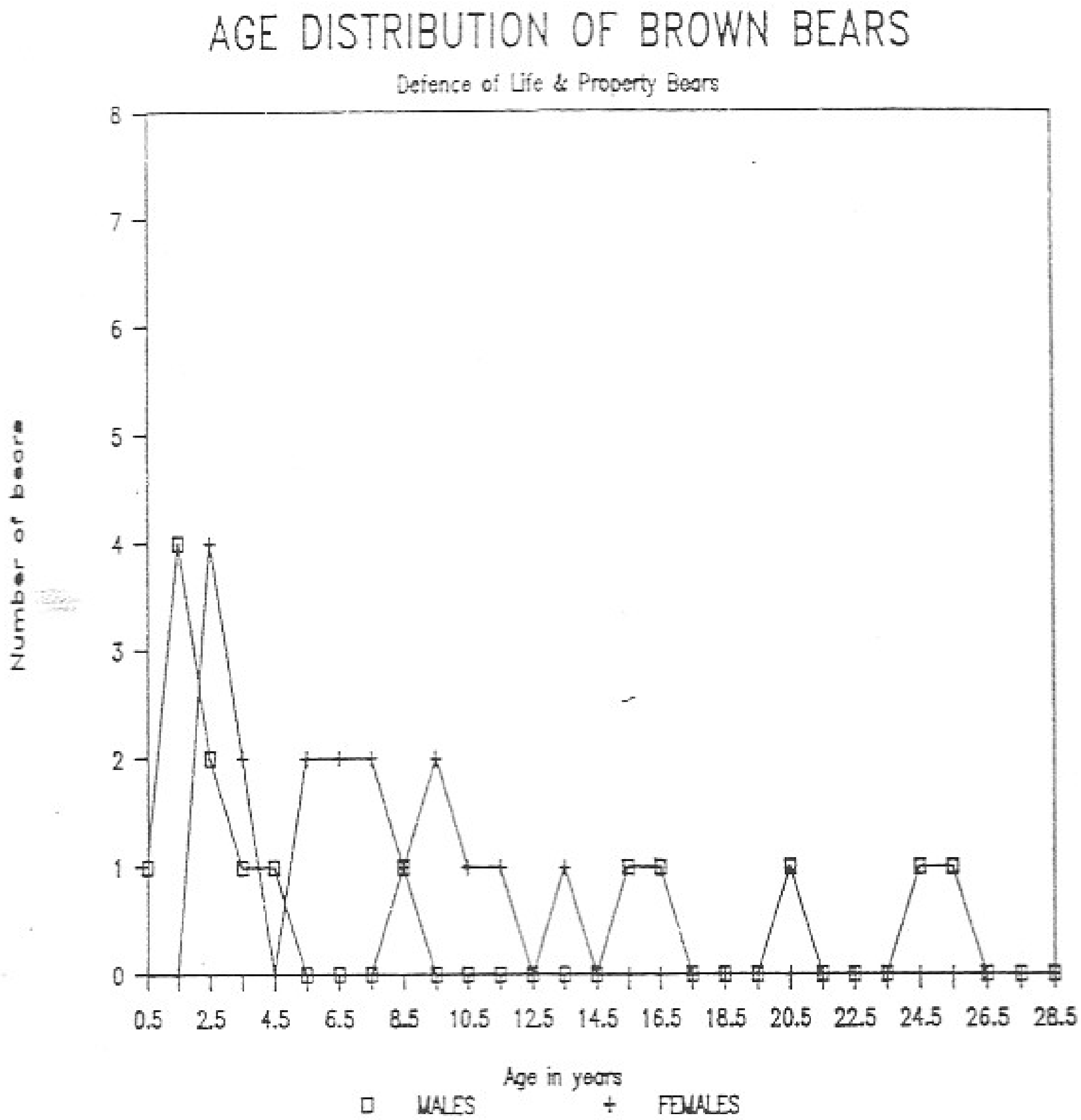


Figure 22. Age distribution of brown bears killed in defense of life or property (DLP) on the Kenai Peninsula, Alaska, 1967-1987.

Tagged Bears in the Harvest

In 1978, 4 brown bears were radio-collared in unit 15A. Of these, one bear was killed in the harvest in September, 1980. In the years from 1984 through 1987, 13 bears were tagged, 3 of which were killed in the harvest (Table 1). In both cases, this represented at least a 20% return of tagged animals, assuming no loss of marks.

Allowable Human-Caused Mortality

Using Bunnell and Tait's (1980, 1981) model, an estimate of natural mortality in adult bears of 5% (Harris 1984), and a population estimate of 300, I calculated that maximum human-caused mortalities per year could not exceed 21 bears (Table 10). Human-caused mortalities could not exceed 14 if the population size was 200 and could not exceed 7 if the population size was 100. The maximum human-caused mortality was therefore estimated at 7% and included sport harvest, DLP's, illegal and unreported kills.

RCR Trail Survey

The RCR trail system received approximately 5800 visitors per year. Trail use on the RCR trail system did not change significantly (ANOVA: $P = 0.97$) from 1984 through 1986. The heaviest use of the trail occurred on the Russian River portion of the trail system, from the trailhead to lower Russian Lake. An average of 7 brown bear and 35 black

Table 10. Estimated maximum number of human-caused brown bear mortalities that could occur annually given a specified population size, a 12% maximum mortality rate and a natural mortality rate of 5% for adults.

Popul. size estimation	total mortalities @ 12%	natural mortalities @ 5%	human-caused mortalities allowable *
100	12	5	7
200	24	10	14
300	36	15	21

* Human-caused mortalities include harvest, defense of life or property deaths, unreported deaths and illegally killed bears.

bear observations per year were reported by visitors. In the spring, both brown and black bears used the area between Cooper Lake and upper Russian Lake. During the summer 86% (n=28) of the brown bear sightings occurred between upper and lower Russian Lakes. The Aspen Flats area, which is along the Russian river between the lakes, was the most common place that campers observed brown bears.

DISCUSSION

Tagging Efforts and Telemetry Data

Relocations

Brown bears seemed to move randomly in the spring. This may be a result of the wide distribution of spring bear foods on the peninsula. Wide distribution of staple foods may have allowed bears to move further to find preferred foods such as winter-killed moose or caribou. Movements of radio collared bears to winter/wolf-killed carcasses were observed. Peterson et al. (1984) documented that brown bears regularly visited wolf-killed moose. Bears moved to salmon streams by mid-June and generally fed on salmon until late fall. During the fall, scats containing cranberries were present along the salmon streams. This indicated that although salmon were a major food, berries were eaten also. During the moose and caribou hunting season, brown bear movements to gut piles were common.

Habitat use varied seasonally and bear observations in specific areas varied throughout the year. In general, areas that provided adequate supplies of food and had low levels of human use, had the most bear observations. The benchlands west of the Kenai Mountains and south of Skilak Lake had the most observations of brown bear and probably received the lowest amount of human use. Salmon were seasonally abundant as they spawned in shallow streams that originated in this area. The western portion of GMU 15A also had abundant salmon but brown bear observations and use were less frequent. I speculated that high levels of human activity and access reduced brown bear use of this area.

Activities by humans along the western slopes of the mountains were dispersed. This area provided den sites and adequate spring and fall food supplies along lower portions of the mountains and on steep slopes below glaciers.

Home Range

Home range estimates for males and females were similar to estimates from the Nelchina (Miller and Ballard 1980), Susitna (Miller 1987) and southcentral (Ballard et al. 1982) studies in Alaska. Males had very large home ranges in these areas while female ranges were less than half the male's size (Table 11). Home range sizes for male bears were so large on the peninsula that bears could frequently come into contact with human activities. Why these bears roamed extensively when heavily concentrated food sources were available in the summer was not fully understood. On Admiralty and Kodiak Islands where salmon were also available in large concentrations, average male home range sizes were 72 km^2 and 230 km^2, compared to 949

Table 11. A comparison of home range estimates (km^2) for several different locations in Alaska where salmon are present.

location	ADULT males(n)	ADULT females(n)	SUBADULT males(n)	SUBADULT females(n)
Kenai Pen.	949 (4)	401 (6)	no data	
Alaska Pen.[1]	262 (6)	293 (30)	749 (5)	244 (6)
Nelchina[2]	850 (6)	415 (4)	848 (4)	118 (1)
Susitna[3] Hydro Proj.	1014 (10)	294 (4)	1218 (14)	320 (7)
Kodiak[4]	230 (8)	26 (16)	51 (4)	
Admiralty[5]	72 (8)	39 (17)		

[1] Glen and Miller 1980, [2] Miller and Ballard 1980, [3] Miller 1984, [4] Smith and Van Daele 1984, [5] Schoen and Beier 1987.

km^2 for Kenai bears. One difference between these areas and the Kenai, that might contribute to larger male home range sizes on the peninsula, was the density of the population. Kodiak and Admiralty bear populations were estimated at 1 bear/4 km^2 and 1 bear/2.7 km^2, respectively (Smith and Van Daele 1984, Schoen and Beier 1987). A density estimate for the Kenai population was though to be approximately 1 bear/34-57 km^2 for the area of highest bear use.

Denning Chronology and Ecology

Throughout their range brown bears typically den in steep, undisturbed areas that have good snow retention characteristics (Craighead and Craighead 1972, Vroom et al. 1980, Servheen and Klaver 1983). Research conducted in southeastern Alaska (Schoen and Beier 1987) and on Kodiak Island (Smith and Van Daele 1988) suggest that in south-coastal areas of Alaska where winter temperatures rarely fall below -20°C, snow may be less important for insulation than in other areas. It is believed that bears in coastal areas need dry, cold sites where temperatures generally remain below freezing and surface water is rare.

Den sites on the Kenai Peninsula were located on less steep slopes than den sites on Admiralty Island, Chichagof Island, (Schoen et al. In Press) and in the Susitna hydroelectric study (Miller 1987), but our sample size was small. Elevation of den sites was less on the average than

but were within the same range. The
and elevation of den sites may have
es in the areas themselves and not den
rs.

increasing bear population reports of
ild increase as the human population
, the number of reported bear sightings
d not provide accurate information
undance of bears unless the number of
However, reported sightings provided
as that were used by bears.
oservations helped identify areas where
were likely to occur. Most ground
areas with high human visitation; these
agement attention to reduce DLP deaths.
ons from the Anchor River area (Fig. 5)
lack of reported sightings and not low
erman, Pers. Comm.).
er of 2.5 or 3.5 year-old offspring
e was greater than the average number
observed. This seems unusual since the
er of 2.5 or 3.5 year old's per female
ne number of cubs or yearlings due to
(1981) explained this situation by

noting that 2.5 year old bears were easier to see than yearlings and yearlings easier to see than cubs. Therefore, the observed litter sizes increase as the young become larger, less secretive and move greater distances. Most of our observations were made from the air making it more probable to miss smaller bears due to the presence of dense vegetation. Litter sizes on the peninsula were similar to others reported in the literature (Table 12).

Ground Surveys

Salmon Stream Surveys

Streams and rivers did not have large concentrations of brown bear use like those found in other parts of coastal Alaska (Troyer and Hensel 1969, Egbert and Stokes 1976, Miller 1987, Schoen and Beier 1987). Some radio-collared bears traveled large distances (>50 km) in the summer to use several different salmon streams. Therefore, the same bear tracks could have been counted twice, even if the tracks were large distances apart. This points out the inherent weakness of using track count data to determine anything but presence or absence. Even relative magnitude of bear use along a particular stretch of stream is confounded by quality of a substrate (i.e. can tracks be recorded in the substrate).

Table 12. A comparison of brown bear reproductive data from similar areas in south central and southeastern Alaska.

	Reproductive data		
location	average litter size	age at first parturition	breeding interval
Kenai Pen.	1.81 n=53 [1]	5.0 years	3.4 [4]
Susitna Hydr.	2.1 n=19 [2]	5.2 years	3.4 n=17
Nelchina	2.8 n=4 [3]	4.7 years n=6	

[1] estimated from observation data.
[2] estimated from capture and telemetry data (Miller 1984).
[3] estimated from capture and telemetry data (Miller and Ballard 1980).
[4] breeding interval was 4.4 for 1 radioed female but the large proportion of 2.5 year olds in the harvest is evidence that the interval is probably 3.4 years.

Habitat Evaluation Surveys

Spring bear foods used on the peninsula were most similar to those reported in southeast Alaska, and the Alaska Peninsula. Equisetum spp., Graminae spp., Carex spp. and Juncus spp. were used in nearly all North American ecosystems during all seasons. Wild ungulate carrion was also consumed by bears in many of the ecosystems in North America (Mace 1987). Brown bear on the Kenai Peninsula have been effective predators on moose (Franzmann et al. 1983)

Aerial Surveys

The aerial surveys conducted on the peninsula had a lower (1.3 bear/hour) rate than those conducted on Admiralty Island (26 bears/hour)(Schoen and Beier 1987). Rates of bear sightings were lower because the Kenai had a lower density of bears and dense vegetative cover bordering many of the salmon streams.

The dense vegetation prevented the use of a line transect method to estimate population size and density. A modified mark recapture technique developed by Miller et al. (1986) may be the best way to determine population size and density. However, Jacobs et al. (1988) recognized that so few bears were present in high use areas on the peninsula that a sample size of marked bears was probably insufficient to produce a meaningful estimate.

Mortality Data

Brown Bear Mortality

The relationship between moose hunters and brown bear harvest was weak for GMU 7, 15A, and 15B, but the increase in bears taken in 15C was partially explained by the increase in numbers of moose hunters in the field. GMU 15A had many moose hunters but relatively few bears so a positive relationship was difficult to detect. GMU 15C had many moose hunters and more bears, thus a significant relationship was easier to detect.

Increased numbers of bears in the harvest were probably a combination of several factors, one of which was an increase in the number of moose hunters. The opening of a spring bear season in 1978 added to the total harvest by increasing the number of hunting days. Improved access probably also played a part in increased bear harvests.

Another explanation for the increased number of harvested bears might be an increase in the bear population. If this was the case, males should have been harvested in greater proportion than females because of differential vulnerability (Bunnell and Tait 1980,1981). Further, the evidence did not support the possibility of an increasing bear population (i.e. higher density of bears). Aerial surveys, ground surveys, and tagging efforts showed relatively low densities of bears on the peninsula. When long-time residents were interviewed most believed bear observations had decreased.

Although the data do not support an increasing brown bear population argument, they do not necessarily support a decreasing population either. However, more bears are being harvested annually without sufficient information to determine whether or not the population can withstand the present level or trend in mortality.

Most harvested bears came from GMU 15B and 15C. This was not surprising because these two areas had the largest proportion of the salmon fisheries and in general contained the largest uninhabited tract of brown bear habitat on the peninsula. The combination of these two factors probably made 15B and 15C the best brown bear habitat on the peninsula.

Sex Ratio and Age Distribution of Harvested Bears

A 1:1 sex ratio in cubs was reported in studies conducted in Alaska (Troyer and Hensel 1969, Wood 1976, Glen 1975, Smith et al. 1984, Miller 1987). Assuming a 1:1 sex ratio at birth, a harvest of 1:1 within a single cohort was not difficult to understand in theory, although it was difficult to detect in reality. The theory, however, provided us a rough idea of what the age distribution of harvested bears should have been given the sex related vulnerabilities (Bunnell and Tait 1980, 1981).

Males were assumed to have a higher vulnerability to hunting than females for 2 reasons. First, males travelled more, tended to disperse greater distances and used larger home ranges than females. Home range data collected on the peninsula supported this contention. Thus, males had a greater probability of encountering a hunter or having a home range that overlaped with a human dwelling. The second reason males were more vulnerable was a result of the harvest strategy. On the Kenai Peninsula, it was illegal to kill a female with a cub or yearling. The result was that a female of reproductive age would only be available for harvest once every 3-4 years (excluding the possibility of lost cubs). Therefore, a greater proportion of males should be shot at a younger age, and a greater proportion of females should generally be harvested at an older age.

The Kenai Peninsula harvest data were inconsistent with this expected age distribution and sex ratio. An explanation for the apparent reversal of the expected age distribution and sex ratio was most likely due to the actual vulnerabilities of male and female bears on the peninsula. Interpretation of sex ratios and age distributions of harvest data have been discussed in detail (Fraser 1976, Bunnell and Tait 1980, 1981, Fraser et al. 1982, Harris 1984, Harris and Metzgar 1987). Analysis of sex ratio and age distribution data from 1961 to 1987 on the peninsula provide no clear conclusions. However, adult females seemed as vulnerable as adult males in the harvest. A possible cause for this could be heavy hunting pressure with no selection for large male bears. Most ADF&G biologists believe that the Kenai Peninsula hunters were not selective for males because trophy-sized bears were uncommon and most bears were shot incidentally while hunters were looking for moose. This may partially account for more females in the harvest, but considering that a female with a cub or yearling was protected from harvest, males should still have predominanted in the harvest.

Interpreting changes in the age-structure of harvest data can be misleading where sample sizes each year are small (Caughley 1974, Harris 1984). Age distributions are highly variable and can create ambiguous results. However, computer simulation models can help to verify symptomatic changes in age-structure due to overharvest. An overharvest of a population can cause changes in age-structure patterns in 3 general ways; 1) the proportion of females in the harvest increases; 2) the ages of harvested males decreases; 3) the ages of harvested females slightly increases (Harris 1984, Miller in press).

The sex ratio for the past 9 years was 0.9:1 (males:females) despite an expected higher vulnerability of males. The proportion of females in the harvest increased from 1970-1978 to 1979-1987. Females seemed equally vulnerable at ages 1.5 to 3.5 and more vulnerable than males at ages 4.5 to 11.5. An increase in the proportion of females and equal vulnerability in the harvest was consistent with a pattern of overharvest (Harris 1984, Miller in press).

Females were not represented in the older age classes (i.e. >17.5 years) in 27 years of data. Where are the old females? This does not appear to follow the general pattern for an overharvested population (Harris 1984, Miller in press).

Subadult to adult ratios in both males and females fluctuated over four 5-year intervals (Table 9), but samples were very small in the earlier years. When the changes in the ratio were examined from 1978-82 and 1983-87 there was an increase in subadult males and a decrease in subadult females. This pattern was consistent with the criteria of an overharvested population. However, when the data was grouped into 10-year intervals and examined for changes (i.e. 1967-77 and 1978-87), the opposite change was observed. Conflicting data exemplifies the need for caution when interpreting age distribution data.

Sex Ratio and Age Distribution of DLP-killed Bears

Bears shot in defense of life or property had a similar age distribution to sport harvested bears. Both males and females were equally vulnerable in the younger age classes and females were more vulnerable than males in age classes 5.5 to 11.5. However, DLP-kills should consist of a higher proportion of females of reproductive age because they are protecting young. Another similarity to the harvest data was that all very old (>17 years) bears taken in DLP conflicts were males.

Tagged Bears in the Harvest

Although the data were inadequate to statistically test the number of tagged bears returned in the harvest, it did suggest a substantial rate of kill. Considering that half of the tagged bears were not legally available for harvest (i.e. females with cubs or yearlings), the number of tagged bears shot seemed high.

All tagged bears that were killed in the harvest were males. Bears captured in remote areas of the peninsula were harvested in areas easily accessible by humans, usually near roads (Fig. 23). These results support Knight's (1987) idea of "population sinks". Knight found that bears in Yellowstone park with home ranges that overlapped townsites and developments were drawn into contact with humans, often resulting in their removal from the population. If developments and easy-access areas that lie within a bears home range act as "population sinks", measures to reduce their attractiveness to bears are needed. The large home range size of bears on the peninsula increases the potential

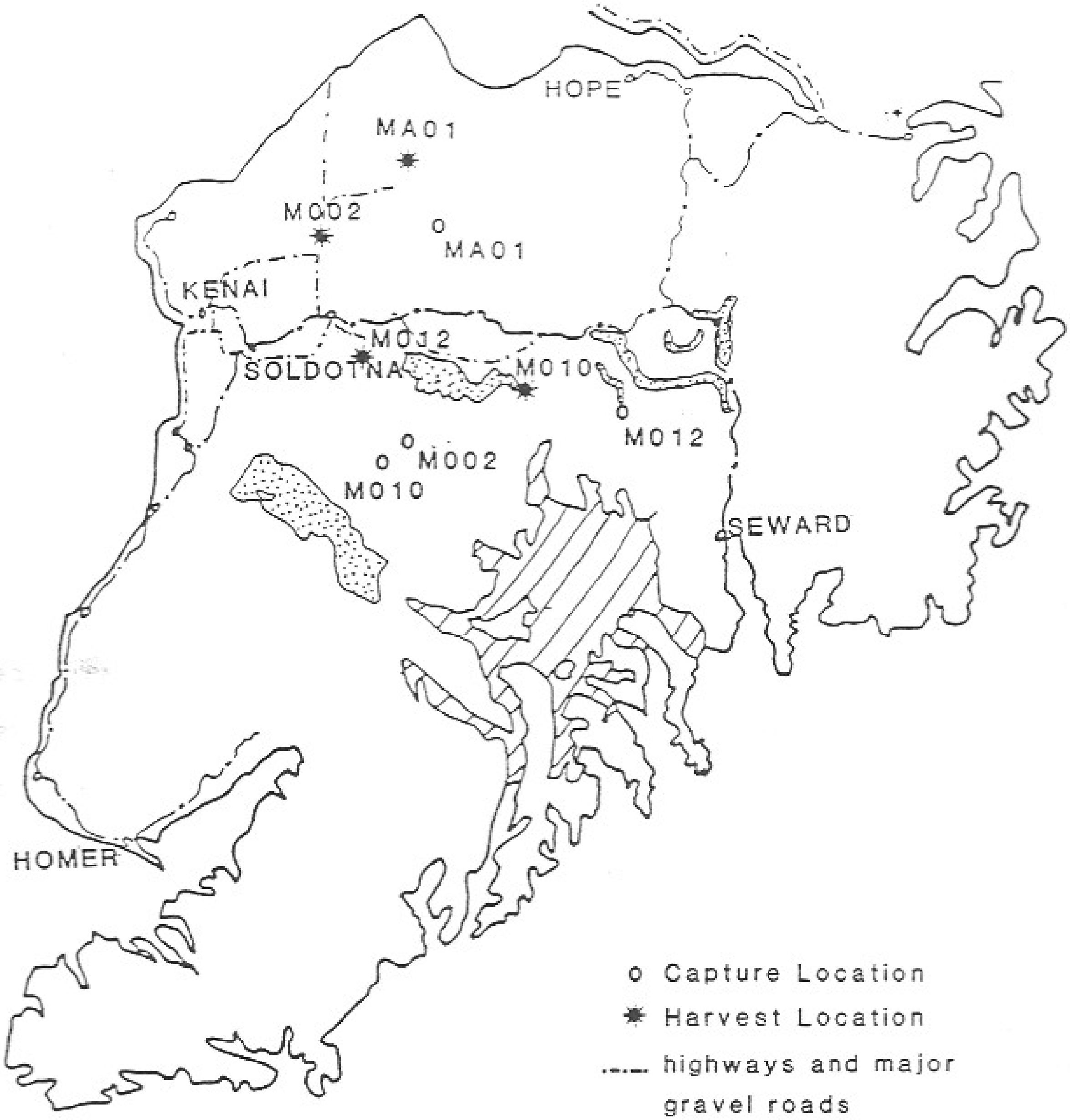


Figure 23. Capture locations and harvest locations for 4 tagged brown bears returned in the harvest on the Kenai Peninsula, Alaska.

effect of "population sinks" associated with areas of high human use.

Allowable Human-Caused Mortality

There are 2 major sources of mortality; natural (i.e. old age, disease, starvation, injuries) and human-caused (i.e. harvest, DLP, poaching and unreported kills). Natural mortality generally is considered low for adult bears (Bunnell and Tait 1981, 1985). Once bears reach 3.5 - 4.5 years their natural mortality rates are low until they become very old (i.e. 21 years). Estimates of natural mortality do not exist for the Kenai population but an estimate of 5% was used (Harris 1984). Therefore, 7% of the mortalities could be caused by humans.

During the past 3 years, an average of 16.3 known bear mortalities occurred per year. The number of unreported kills and fatally wounded or poached bears was unknown. Because this unknown segment should be included to determine the total human caused mortalities, it is likely that the number of mortalities was greater than 16.3. Without the additional unknown mortality we are exceeding the estimated maximum human-caused mortality level (7%) for 2 of the 3 scenarios (Table 10).

Brannon et al. (1988) estimated that 2.9% of the reported grizzly bear mortalities were unreported kills and 8.4% were illegal kills in the Northern Continental Divide

Ecosystem (NCDE). Although the peninsula population may not receive the same proportions of unreported and illegal kills as the NCDE, it is doubtful there were none. An estimate of unreported and illegal bear kills using Brannon's et al. (1988) estimate would be 1-2 bears per year. Depending on how many bear mortalities were unreported, poached or fatally wounded, the number of human-caused mortalities may be exceeding levels for all 3 of the scenarios.

With a population of 200 bears I estimated a maximum human-caused mortality rate of 14 bears/year. After subtracting estimated unreported or illegal mortalities from the total, the estimate of maximum reported mortalities (i.e. harvested and DLP deaths) was 12-13 bears/year.

Using natality rate and age at first parturition to determine an appropriate maximum mortality rate for a given population may not be completely safe. By use of simulation models, Harris (1984) found that population size was important in determining how much mortality a given population could withstand. This makes intuitive sense, knowing how slow the recovery rate is for bear populations. As population size decreases, the level of mortality a population can withstand decreases even though other parameters remain constant. This was a good reason to take a conservative approach to management for Kenai brown bears and therefore I recommend that reported human-caused mortalities should not exceed 10-11 bears/year.

RCR Trail Survey

Human/brown bear encounters on the trail system have not resulted in maulings or attacks. However, increases in the amount of human activity in the area could displace bears from the area (Gunther and Renkin 1985) and/or increase the possibility of dangerous human/bear encounters. The high proportion of brown bear observations in the Aspen Flats area during the summer was a result of many hikers, good visibility and good bear habitat.

CONCLUSIONS

Although data were limited, the brown bear population seems to be at low densities as determined from aerial surveys, ground surveys, and tagging efforts. A zoning strategy to protect important brown bear habitat and a change in the harvest strategy is recommended.

Current brown bear habitat is shrinking because of human encroachment by roads, developments and land disposals. Efforts should be made to protect remaining bear habitat from further reduction. Special attention should be given to salmon spawning sites that are currently used by bears.

The number of bear mortalities doubled in recent years and could be at or exceeding the estimated maximum mortality rate suggested for the Kenai population. An increase in moose hunter numbers, yearly brown bear hunting season length and easier access probably contributed to this trend. A higher proportion of females (>50%) were killed in the harvest during the same time period that the number of harvested bears doubled. This may be reason for concern assuming the sex ratio at birth is 1:1 and may indicate heavy hunting pressure. Until more information is available I recommend a very conservative management approach be used.

The hunting season should be modified to reduce the total number of brown bear mortalities to 10-11 and reduce the proportion of females killed to 30%-35% annually.

More brown bear research should be conducted. This research should focus on population estimation and a more detailed analysis of the cumulative effects of human development on the bear population. Mapping the peninsula using ARC-INFO techniques would provide land managers an opportunity to simultaneously view a combination of variables. Important variables to consider are roads, subdivisions, mineral leases, potential logging sites, grazing leases, hunting cabins, trails, salmon spawning sights, den sites, and various habitat features. This would enhance the ability of a land manager to make management decisions.

The RCR trail system is located in essential brown bear habitat. The potential remains high for human/bear encounters to occur on the RCR trail system and therefore close attention should be given to the area with respect to visitor use. Hikers and campers should be informed about brown bears before they visit the area. An aggressive education program should be developed (i.e. trailhead signs, pamphlets, trail rangers communicating with the public). Enforcement of camping regulations (i.e. safe food storage, designated camping sites and cabin use) is important to reduce conflicts with bears.

Continued monitoring of visitor numbers, by use of trail counters, is highly recommended at 3-5 year intervals. Bear/human encounters should be recorded yearly so detection of trends are possible. Yearly records also will elucidate a shift or change in the locations of bear encounters. A Limits of Acceptable Change (LAC) (Stankey et al. 1985, McCool et al. 1987) format should be considered for the trail system to determine the character and future direction of recreational activities. The LAC format places emphasis on desired conditions for an area rather than how much use it can sustain. Other trails where potential bear/human conflicts can occur should also undergo LAC evaluation.

BROWN BEAR MANAGEMENT

Management of brown bears is difficult. The basic techniques that biologists use to manage animal populations are not easily employed with brown bears. Without sufficient information biologists should make conservative management decisions, especially for a species with a low recovery rates. Conservative management can be identified from the management strategies used to manage low density brown bear populations in the lower 48 states and Canada. Conservative management can reduce the risk of making an error in judgement. Some of the risks that Kenai Peninsula brown bear biologists currently face are: 1) lack of reliable population assessment methods that would work on the Kenai; 2) maintaining genetic diversity and demographic stability in a small population of brown bears; 3) determining how to address continued land development and human activity in brown bear habitat; 4) a large proportion (>50%) of females are being harvested.

Population size and densities are very difficult to measure by means of line transect, capture-recapture, track counts and other methods, because of the excessive time, energy and cost required to obtain an accurate estimate. This is especially true for small populations of bears such as the Kenai population. Estimates of sex ratios, survival rates, and age distributions vital in guiding the harvest of a population are based upon sample sizes that are generally inadequate. Therefore, management decisions should be made with more than population parameter estimates alone. Biological intuition and an understanding of the cumulative effects of human activities on mortality and habitat loss should also accompany management decisions

Current literature emphasizes specific concerns with regard to maintaining viable populations. These concerns are demographically and genetically related and argue that some species risk extinction if the population lacks demographic stability or genetic variability. Environmental or human-caused stochasticity are random events that can induce demographic or genetic change in a population. These events can be most critical to populations at low numbers. The result of a change in demography may result in a population's inability to reproduce. A genetic change may result in a reduction in genetic variability through founders effect, genetic drift and inbreeding depression (Schoenwald-Cox et al. 1983).

Although brown bears seem to have genetic variation in North America (Knudsen and Allendorf 1985), genetic diversity may be low on the Kenai Peninsula because the population was poisoned in the early part of this century (KNWR historical report 1938) which reduced the population to low numbers. Further, immigration and emigration is probably minimal. This may or may not be a problem, but it should not be ignored.

To reduce the probability of demographic or genetic demise, bear populations must be managed above the minimum viable population (MVP) size. A MVP for selected species has been discussed in detail (Shaffer 1981,1983, Lehmkuhl 1984, Shaffer and Samson 1985, Suchy et al. 1985, Reed et al. 1986, Conner 1988). For brown bears an effective population size of 50 to 125 individuals is estimated to prevent negative inbreeding effects and assure short-term survival (Suchy et al. 1985, Shaffer and Sampson 1985). An effective population size of 500 individuals is estimated to prevent genetic drift and assure continued, long-term, adaptation (Soule 1980, Shaffer and Sampson 1985). Simulation models used to determine MVP have increased the ability to determine the effects of changes in mortality and fecundity rates with respect to the survival of a population (Shaffer 1981, Harris 1986). However, point estimates for a MVP size should be viewed with caution.

Even if a population goal is selected, above a specified MVP size, the problem of determining the current status of the population remains. Population parameters (e.g. size, density, sex ratio, etc.), will remain difficult to measure with any accuracy. Questions such as, "how much human-caused mortality can the bear population sustain", "what amount of development or recreation will jeopardize essential habitat" and "how much suitable habitat is needed to support a viable population" are the important issues that need to be determined. Information needed to provide a starting point for these questions is the data collected by the IBBST over the past 4 years. This information provided insight on the current distribution, movements, and relative abundance of brown bears on the Kenai Peninsula. Combining this information with current land use practices can help develop a cumulative effects analysis model.

A cumulative effects analysis (Weaver et al. 1985, USFS 1986) is an accepted method of determining how resources and environments change both naturally and from human activities. By analyzing these changes it is possible to evaluate the combined human impact on resources due to many types of activities. This analysis provides a clearer picture for land managers and enables them to see the probable results of their management decisions.

A large proportion of females in the harvest may indicate excessive hunting pressure and measures to reduce the number of females killed annually is suggested.

General Recommendations

Considering the available data and its limitations, and the desirability of assuring the survival of a brown bear population in the future, protection must be provided for essential brown bear habitat. Management of the Kenai population would be best accomplished by retaining a large area of undeveloped land: 1) along the western slopes of the Kenai Mountains, including the Chickaloon drainage 2) in the benchlands between Skilak and Tustumena Lakes, 3) the headwaters of Deep Creek, Ninilchik, Anchor and Fox Rivers, 4) the Snow River/Nellie Juan drainages, and 5) Johnson and Bench Lake areas on the eastern side of the peninsula. Corridors of habitat should be designated to connect these areas to ensure that areas of brown bear habitat are not isolated.

Harvest objectives should change for the peninsula. The need to reduce the number of females taken in the harvest should be addressed. This would decrease the risk of overharvest. Overall harvest should be reduced because population size and density are unknown but appear low. Natural mortality estimates for Kenai bears do not exist and age specific survival rates are unknown. A conservative strategy is logical when managing a species with a low recovery rate.

The major actions for managing Kenai brown bears should be:

1) Provide a large enough continuous land base (suitable habitat).
2) Eliminate or minimize disturbances in areas essential or seasonally important to bears.
3) Set a conservative harvest and reduce DLP conflicts.

If these three items are accomplished the crude methods of determining population trends would provide acceptable information because the critical variables for the bears' survival would be satisfied giving us a larger margin of error.

The Management Strategy

As the human population increases on the Kenai Peninsula, it becomes increasingly important to manage those types of human activities that negatively affect brown bear populations. The brown bear management strategy consists of two facets.

1) Zone the Kenai Peninsula to reflect differences in the areas importance to brown bear.

2) Modify the harvest objective in response to expanded information about brown bears on the peninsula.

Zoning Strategy

Zoning the Peninsula to manage bears is more accurately described as zoning to manage people. Zoning is the most effective way to provide the necessary protection of areas that are essential to bears. Three types of zones (essential, secondary or corridor and nonessential) were designated from IBBST research with regard to an areas importance to the population's survival. Some areas had high use by bears and provide a critical source of food, cover and space. These areas were designated as essential zones. Other areas had low or seasonal use or provided necessary travel routes across the peninsula. These were designated as secondary or corridor zones. Existing townsites, permanent campgrounds, and areas of high human use generally were not considered important to brown bears and were designated as nonessential zones. Each zone has different management objectives. Criteria for determining the amount of area that each type of zone should encompass was based upon: (1) research addressing disturbance and displacement of North American brown bears by human activity; (2) estimates of the amount of habitat needed to support the desired population of bears and; (3) a realistic view of Kenai Peninsula land ownership.

Specific recommendations are outlined with respect to human activities, for each of the zones. Because the IBBST has no managing authority as a group, recommendations should be used as a guide for the individual agencies. Activities addressed are: road management, recreation (non-consumptive), mining, oil and gas exploration and development, housing development, timber operations, livestock grazing, garbage disposal, and aircraft disturbance (Fig. 24).

The desired minimum population size for the peninsula should be 300 bears. This would meet the requirements of a MVP size and provide a suitable density of bears on the peninsula. Food supply is probably not a limiting factor on the growth of the Kenai population. However, human activities and their associated impacts are. Therefore, I suggest the protection of 8800 km^2 for bear habitat. This area would be protected as either essential, secondary or corridor zone. The protected area would be adequate for 300 bears as long as human activity is not excessive. If 300 bears occurred within the protected area, it would yield a density of 1 bear/29 km^2; close to the density reported by Miller (1987) for the Susitna area.

Essential Zone

Essential zones should be maintained in the most natural state possible. The purpose for this zone is simply to protect areas that are essential to the brown bears' survival. Protecting bears from disturbances that cause displacement and non-sport kills are of principal concern. Disturbance is most likely to occur from June through October when bears are feeding on salmon. Preventing development and limiting recreation in close proximity to these important areas will provide protection for both bears and people.

The largest portion of the essential zone designated for the peninsula lies within the Kenai National Wildlife Refuge and is managed as wilderness. Therefore, many of the recommendations are already in place for those areas. Essential sites outside the refuge are most vulnerable and in need of the most cooperation by the other land management agencies.

Management recommendations for essential zones are:

1) Maintain roadless conditions. Roads are considered to have a major impact on brown bear populations (Schallenberger 1976, Elgmork 1978, Jonkel 1982, Miller and Ballard 1982, McLellan and Shackleton 1988). Roads provide easier access for humans and hunters. Increased activity can cause displacement or avoidance of roads and surrounding areas which results in habitat loss. Where bears are habituated to roads, roads would provide a travel route to housing developments. This would increase the probability of human-bear encounters.

Existing roads should be closed to motorized vehicles. In some areas, such as designated wilderness on the refuge, motorized vehicles are already prohibited.

2) Allow camping, but sensitive areas (i.e. areas where the risk of a human/bear encounter is high), should be closed to hiking and camping at certain times of the year. Recreational activities previously thought to cause little or no impact on bears (i.e. hiking and camping), can cause displacement (Schleyer et al. 1984, McLellan and Mace 1985, Gunther 1986). The IBBST observed that brown bears left salmon streams after 4 days of snaring, even though transmitters were attached to the snares to reduce the number of visits by personnel to the stream. Bear activity was determined by the presence of fresh tracks.

Developments such as additional recreational cabins should not be built along trails in this zone as they can increase the probability of human/bear encounters.

3) Prohibit oil, gas, or mineral extraction except for existing walk-in mining claims. Road construction and the subsequent availability of access is the major problem with these types of developments (Schallenberger 1980, Jonkel 1982, Nagy et al. 1983). Avoidance of roads and the resulting habitat loss has been shown to be independent of traffic volume (McLellan and Shackleton 1988). The process of extraction is not necessarily the cause of displacement (Schoen 1986, USFS 1980). However, Harding and Nagy (1980) found that hydrocarbon exploration disturbed denning areas and caused abandonment.

4) Prohibit the construction of subdivisions or recreational cabins. Where subdivisions or recreational cabins already exist, garbage should be removed or incinerated quickly. Seasonal restrictions on use of recreational cabins in essential zones should be considered. The public should be educated about bear management objectives and methods for discouraging visitation by bears. Bears are not inhibited by housing or cabin developments if cover is present (Jonkel et al. 1978). Housing developments introduce garbage that can attract bears, eventually habituating them to this type

of food source (Servheen 1981). Subdivisions can also act as "population sinks"; areas that are within a bear's home range and therefore increase chances for human-bear conflicts (Knight 1987).

5) Prohibit logging operations. Existing logging roads should be closed to public access. Prescribed burning or "let burn" policies are acceptable practices and should be encouraged.

Some logging cuts are advantageous to bears because they stimulate growth of preferred bear foods (USFS 1986, Holland 1986). However, timing of the cut, placement, and careful management of access are extremely important to reduce negative impacts. In most cases the negative effects caused by roads outweigh the positive effects of additional food plants. This is particularly true for a population that already has a reliable concentrated source of food (i.e. salmon) such as the Kenai population. Therefore, I do not recommend logging in essential zones.

Roads that provide access to timber cuts have the greatest impact to brown bears (Jonkel 1982). Human use of a logged area will almost certainly increase even after the cut is completed because of these roads (Craighead 1980, Archibald 1983). Continued human use eventually displaces brown bears or could end in a human-bear conflict.

Prescribed burns can be advantageous to brown bears by enhancing growth of fruiting shrubs, grasses and forbs (Bratkovich 1986, USFS 1985c). Burns can be placed and timed to reduce impacts on brown bears (i.e. not near denning sites, fall feeding sites). Prescribed burns normally occur along existing roads or are done in remote areas by heli-torch. Therefore, this does not increase human access.

6) Prohibit livestock grazing. Grazing livestock in bear habitat has several negative impacts. Riparian areas along stream sides, seeps and springs are trampled and soil is compacted, reducing the productivity of fruiting shrubs, grasses and sedges (Jonkel 1982). Competition occurs between livestock and bears for spring grasses and sedges (Servheen 1981). Bears will prey on livestock an thus livestock act as attractants, drawing bears into conflict with humans.

7) Enforce proper sanitation procedures in all bear habitat. Garbage and food should be stored out of reach of bears. Noncombustible garbage should be packed out. Bear-proof containers, raised platforms and meat poles are suggested for outfitters (Wood 1985) and unguided hunters. Cabin users should remove and burn garbage on a regular basis and should bear-proof their cabins (Zager and Jonkel 1980). Education programs (i.e. signs, pamphlets, etc.) for all

back-country users should be expanded (USFS 1982, 1985a, 1985b, 1985c, Brannon 1984).

8) Prohibit harassment by aircraft (fix-winged and helicopter). Disturbance of bears by aircraft has been well documented (Quimby 1974, Harding and Nagy 1980, Smith and Van Daele 1984, Campbell 1985). Specific lakes or portions of lakes should be closed to float planes during peak use by brown bears (see specific recommendations for lower Kenai River Area).

Secondary and Corridor Zones

Secondary zones are defined as areas used by brown bear on the periphery of essential brown bear areas. The primary objective in this zone is to protect areas that are seasonally important. Increased public awareness of the importance and use of secondary zones by brown bears will help to decrease human/bear encounters.

Corridor zones are defined as areas that brown bears use to travel from one essential or secondary area to another. The major function for these zones is to allow for movement of bears to and from areas north and south of the Sterling highway and east and west through the Kenai Mountains. Movement to and from the Kenai Peninsula by brown bears occurs through a 17 kilometer wide strip of land. This corridor should also be managed to allow for movement. Corridors are extremely important because they allow bears to disperse into lower density areas and breed. Movement of bears helps to maintain the genetic diversity of the population. Travel corridors will be the most difficult areas to justify protection. Corridors should be protected from developments because they restrict movements of bears. Housing developments, campgrounds, and industrial developments are potential dangers because they can also increase possible conflicts between bears and humans.

Management Recommendations for these zones are:

1) Close roads seasonally to public access. Road systems should be limited to the minimum necessary to accomplish the purpose (i.e. timber harvest), while enhancing and preserving bear habitat. Roads should be built to minimum standards (USFS 1985a) and constructed to facilitate their eventual closure. Roads should not cut through or parallel riparian zones. Motorized vehicles could be permitted on designated roads or seismic lines at specified times during the year.

2) Allow camping and hiking but encourage educational programs that teach methods of safe food storage and camp cleanliness.

3) Allow limited oil, gas and mineral development and extraction. This type of development should not be active during seasonally important times such as denning, (Schoen 1986). Roads created from these developments should be closed to the public from June through November. Off-site camps are recommended where applicable.

4) Limit the construction of recreational cabins. Bear conservation and public safety should be evaluated before approving cabin construction applications. Determining the cumulative human impacts that persist in the area should help in the evaluation. The LAC format should be used as the decision process.

5) Closely control logging operations and logging road construction. Roads should be closed to the public from May through November to avoid conflicts that could result in DLP deaths. Timing, placement, and type of the cut, combined with careful management of road access, are extremely important to reduce negative impacts. Detailed methods of cutting have been described to enhance bear habitat and reduce negative impacts to bears (Ruediger and Mealey 1978, Mealey 1979, 1986, Jonkel et al. 1979, Servheen 1981, USFS 1983, 1984, 1985a, 1985b, 1985c, Hillis 1985).

Prescribed burns are permitted and should be encouraged where they are compatible with the management of other wildlife and fish.

6) Restrict livestock grazing. Stocking rate and seasonal limits should be placed on all grazing leases. Riparian sites should be fenced off to livestock to prevent degradation. Grazing leases should specifically require measures to protect areas important to brown bears.

7) Proper sanitation is as important in these zones as it is in the essential zone and should follow the same guidelines.

8) Prohibit harassment by aircraft. Current regulations should be adequate for management.

Nonessential Zone

Nonessential areas include town sites and heavily used recreational areas on the Kenai Peninsula (permanent campgrounds and public access sites for fishing). This zone is defined as area nonessential to brown bears because displacement has already occurred from human disturbance and settlement or they are absent from the area. These areas are used occasionally by brown bears, but management of bears in these areas is not considered a primary management goal.

Management recommendations for this zone should focus on educating the public and developing policy to deal with problem brown bears. Recommendations are:

1) Provide educational programs to inform the public about human-bear encounters. This is particularly important in permanent campgrounds and at public fishing access areas. The public should be aware that bear encounters are possible in these areas.

2) Provide bear-proof garbage containers. This will reduce campground habituation by both black and brown bears. Since permanent campgrounds provide garbage cans and dumpsters to the public, it will be necessary to follow a rigid schedule of collection and disposal. Garbage should be picked up late in the day to reduce the amount of garbage left in containers overnight.

3) Establish standard procedures for handling bears that roam into campgrounds, public fishing sites or town sites. Enforcement personnel should be familiar with a standard procedure. The recommended procedure is:

- the reported incident should be promptly investigated by the appropriate government officials.

- if a bear is present in a public area steps to protect human safety should be foremost. The attractant should be removed and action taken to repel the bear with red pepper spray or rubber bullets if necessary. The conditioning of problem bears to avoid human activity should be the initial method of deterring these bears.

- bears that return, and threaten public safety may have to be destroyed. The bear should be trapped and destroyed in a humane way.

ZONE TYPE / ACTIVITY	ESSENTIAL	SECONDARY OR CORRIDOR	NONESSENTIAL
ROAD CONSTRUCTION	-Prohibited	-Not recommend -Build to minimum standards	-Not restricted
RECREATION	-No motorized recreation, -Seasonal back-country campsite closures	-Restricted motorized use -Education programs	-Education programs at public areas
OIL, GAS, MINERAL EXTRACTION	-Prohibited	-Limited development -Seasonal restrictions	-Not restricted
SUBDIVISIONS	-Prohibited	-Evaluation proceeding construction	-Not restricted
TIMBER OPERATIONS	-Prohibited except for burning	-Restricted except for burning	-Not restricted
LIVESTOCK GRAZING	-Prohibited	-Restricted	-Not restricted
SANITATION	-Enforce proper sanitation procedures	-Enforce proper sanitation procedures	-Enforce proper sanitation procedures
AIRCRAFT	-Prohibit harassment, -Seasonal lake closures	-Prohibit harassment	-Prohibit harassment

Figure 24. Proposed brown bear management guidelines for the Kenai Peninsula, Alaska.

Harvest Strategy

The ultimate purpose of each of the proposed harvest alternatives is to reduce brown bear mortalities from all sources and reduce the proportion of females in the harvest. There are several harvest alternatives that could produce these objectives depending upon population status, harvest trends and other demographic features.

1) Establish an upper limit on the harvest of brown bears. Quotas could be set for specific GMU's or overall. A female sub-quota should accompany this upper limit. If the human population on the peninsula increases further, brown bear hunting may increase and a limit should be established. Before Montana instituted a quota system in the Northern Continental Divide Ecosystem (NCDE), the reported sex ratio in the harvest was 53.8% males and 46.2% females (Brannon et al. 1988). After the quota system the harvest data indicate a shift in the sex ratio to 67.8% males, 32.2% females.

2) Shift the brown bear hunting season later into the fall, and prohibit the shooting of all family groups. This would reduce hunting pressure on bears and should reduce the number of females that would be vulnerable to hunters. The overlap of moose and brown bear hunting season should be eliminated or minimized. Gut piles are attractants and

could be a major factor in placing bears in proximity to hunters, increasing the potential for non-selective harvests. As the regulations stand, a female with a 2.5 year old offspring is legal to harvest. Prohibiting the harvest of any family group will provide greater protection of mature females.

3) Eliminate the fall brown bear hunting season. Fewer bears were harvested during the spring brown bear season and they were predominately male. This would meet the harvest objectives.

SPECIFIC AREA DESCRIPTIONS and RECOMMENDATIONS

The Kenai Peninsula was divided into 12 geographical areas. Each area was described individually to facilitate the land manager in finding the specific brown bear management objectives and recommendations. Specific designations for land units within each area are given to provide an even more detailed view of the units. The goal of this format is to assist the land managers in making decisions dealing with the development of areas on the peninsula. Development in the form of human habitation, recreation, oil, gas, and mineral extraction, and timber harvesting will be addressed when applicable.

The maps for the 12 geographic areas were divided up in a grid pattern for ease of locating a specific area (Fig.25, 25a). Each of 19 maps represents a portion of the peninsula with respect to geographical area, land tenure and zoning. Maps are located directly following the area recommendations and include the following:

SWANSON RIVER	(area A)	CHICKALOON RIVER	(area B)
PLACER RIVER	(area C)	LOWER KENAI RIVER	(area D)
UPPER KENAI RIVER	(area E)	TUSTUMENA LAKE	(area F)
RESURRECTION RIVER	(area G)	NELLIE JUAN	(area H)
ANCHOR RIVER	(area I)	FOX RIVER	(area J)
FJORDS	(area K)	SELDOVIA	(area L)

Area "A" Swanson River

Description

The Swanson River area has the most development in terms of gas and oil extraction on the Kenai Peninsula. The Swanson river oil field lies in the near center of this area. The area is also traversed by many roads, especially in the western two thirds. Major habitat types in the Swanson River Area are lowland spruce and treeless bogs.

Brown Bear Abundance

This area may have once been prime brown bear habitat but it now receives relatively little brown bear use because of the considerable human use. Brown bear use is reported in the area sparsely throughout the summer, with greatest use in the fall. The upper Swanson River and the Swanson Lakes area is of greatest importance. Surveys conducted in the area by IBBST documented few predation sites even though there are large concentrations of red and silver salmon in several streams (Table 13).

Zoning

The western half of the Swanson River area is zoned nonessential and the eastern half is zoned secondary. Several sites appear to be seasonally used by brown bears and are thus zoned as secondary (Maps I-2,I-3). Important sites are portions of Sucker Creek and Pincher Creek.

Sucker Creek receives moderate brown bear use during the fall salmon spawning period.

Management Recommendations

The most important management objective in this area is to protect the secondary zone from excessive human development and activity. Recreationists should be warned about bears and persuaded to take the necessary precautions to avoid conflicts with bears. This responsibility is shared by state and federal agencies since much of the Swanson River area is within the KNWR.

Table 13. Estimated salmon escapements and brown bear use for the Swanson River Area, Kenai Peninsula, Alaska.

Drainage	King Salmon	Red Salmon	Silver Salmon	Pink Salmon	Dog Salmon	Bear Use
Swanson River	0	3000	6000	few	0	low
Sucker Creek	0	*	*	0	0	mod.
Bishop Creek	0	7500	?	few	0	low
Otter Creek	0	0	?	0	0	low
Seven Egg Creek	0	0	?	0	0	low
Pincher Creek	0	0	?	0	0	low
TOTAL	0	10500	6000+	few	0	
Average Spawn		Jul.10	Aug.28	Aug.		

? undetermined escapement
* included in the estimate for the Swanson River

Area "B" Chickaloon River

Description

The Chickaloon River area is located in the north central portion of the Peninsula. This area is fairly remote, however, the Mystery Creek road and pipeline road bisects the area. This road is closed to public access at the Sterling highway except during the fall big game season (August 30 - October 20). The Chickaloon area is chiefly designated as a minimal management area by the KNWR. A portion of the Lowland wilderness unit and the Mystery Creek wilderness unit make up the balance of the area.

Brown Bear Abundance

The Chickaloon River Area is an important area to brown bear during the summer and fall. The Chickaloon River provides some the best spawning habitat on the upper peninsula (Table 14). Because the area provides excellent spawning habitat combined with low human activity it is considered a high-use area for brown bears. Known predation sites for brown bears are located on the Chickaloon River from river mile 7 to 19. There is also bear use at a site on the Chickaloon River that is bisected by the pipeline road. Big and Little Indian Creeks receive salmon runs and some brown bear use. Both of these creeks have small areas in which salmon can spawn before they climb in elevation.

Mystery Creek receives large runs of red salmon but brown bear use was low to moderate.

Zoning

The Chickaloon area is zoned as essential to the north and secondary/corridor to the south (Maps I-3,I-4). The Chickaloon River area should be connected by a managed corridor to the largest continuous piece of brown bear habitat (i.e. the Skilak, Tustumena and Anchor River areas). Therefore, a corridor zone is also designated extending south from this area.

Management Recommendations

Limited access is recommended for the pipeline road. The current fall only opening which provides hunters (mainly waterfall) access appears compatible. The poor condition of the existing road limits its use, and we therefore do not recommend any improvements that would increase human use. The northern portion of this area should be as undisturbed as possible from mid-June to late October. In the southern portion of the area, bear/human encounters are likely near Fuller lake. This is within the proposed travel corridor and hikers, campers and horses should be educated about possible encounters with bears.

Table 14. Estimated salmon escapements and brown bear use for the Chickaloon River Area, Kenai Peninsula, Alaska.

Drainage	King Salmon	Red Salmon	Silver Salmon	Pink Salmon	Dog Salmon	Bear Use
S. Fork Chickaloon	2000	2000	?	0	0	high
N. Fork Chickaloon	600	0	?	0	0	
Lower Chickaloon	0	0	?	50000	0	high
Mystery Creek	1000	6500	?	0	0	mod.
Big Indian Creek	few	0	?	?	0	mod.
Ltl. Indian Creek	few	0	?	?	?	mod.
TOTAL	3600+	8500+	?	50000+	?	
Average Spawn	Jun.15	Jul.10	Aug.15	Aug.15		

? undetermined escapement

Area "C" Placer River

Description

The Placer River Area encompasses the Resurrection Creek drainage and East to Blackstone and Passage Bays. And from Cook Inlet and the Portage Creek valley south to Upper Trail Lake (Maps I-4,I-5). The Seward highway bisects this area along Canyon Creek, East Fork, and Grant Creek.

Brown Bear Abundance

Few brown bears use the Resurrection Creek and Hope region. Nearly all brown bear use is located in the eastern part of the Placer River area. Most bear sightings occur near Bench and Johnson Lakes, and along the Placer river near Spencer glacier. Brown bears use the area from April through November. Anadromous stream escapements are listed in Table 15.

Zoning

The Placer River Area has one region that is designated essential for brown bears. This region is located from Bench and Johnson Lakes to the Placer River. Brown bear observations in this location have been relatively high compared with other areas on the east side of the peninsula. Classifying a part of the Placer River area as an essential zone might seem difficult to understand since the railroad tracks run right through it. However, other than the trains and crews working the tracks this area doesn't receive a large amount of human activity except during fall hunting season.

Retention of a travel corridor both north and south from this essential zone is important to the survival of those bears that use the area. The northern corridor is the peninsula's connection to the mainland. Any immigration that occurs to the peninsula must be through this corridor. From a genetic viewpoint this corridor is extremely important. The southern route that the bears are suspected to use is south along the west or east side of Andy Simons Mountain to Paradise Lakes. If this area was kept in a primitive state the bears would be able to travel from the Placer River to the North Fork of the Snow River to the South fork of the Snow to the Nellie Juan Valley to Kings Bay. The importance of the Nellie Juan Area to brown bears is unknown but it is suspected that bears do occur there.

Management Recommendations

Even though the town of Hope is not in the heart of brown bear range it poses a potential problem because of poor garbage management. It must be stressed that attractants such as open garbage dumps and campground dumpsters that are not bear-proof will draw bears to the area. These bears, usually end up dead. The USFS should bear-proof Porcupine campground and educate the people of Hope with respect to bears. Corridors should be maintained, as described above, according to zoning objectives.

The Johnson Pass trail crosses the area and probably does not pose a threat to the bears because it is away from bear fishing spots most of the time. Visitor use should be monitored for increases and campers should be educated about possible brown bear encounters on this trail.

Table 15. Estimated salmon escapements and brown bear use for the Placer River Area, Kenai Peninsula, Alaska.

Drainage	King Salmon	Red Salmon	Silver Salmon	Pink Salmon	Dog Salmon	Bear Use
Resurrection Creek	500	0	250	35000	0	low
Sixmile Creek	500	0	?	?	?	low
East Fork River	0	0	?	50000	0	low
Granite Creek	1000	0	?	0	0	high
Placer River	0	?	500	0	0	high
Skookum Creek	0	0	?	0	0	mod.
Seattle Creek	0	0	0	?	0	low
Ingram Creek	0	0	0	?	0	low
Portage Creek	0	2500	500	?	?	low
TOTAL	2000	2500+	1250+	85000+	?	
Average Spawn	Jun.15		Aug.25	Aug.1	Aug.	

? undetermined escapement

Area "D" Lower Kenai River

Description

This area encompasses the portion of the Kenai River and its tributaries from the Russian River downstream. This includes the town sites of Kenai, Soldotna and Sterling. Area "D" is the most populated of the 12 areas. Most of the Lower Kenai Area is managed by the Kenai National Wildlife Refuge, however, state, native and private land ownership occur also.

The Lower Kenai Area is located in the rolling Kenai lowlands and provides excellent brown bear habitat. Major habitat types for the area are mixed upland forests, low growing spruce and treeless bogs. Deciduous hardwoods occur along the drainages and in disturbed sites.

Brown Bear Abundance

The benchlands that lie between Skilak and Tustumena Lake probably has the highest density of brown bears on the peninsula. Salmon are available in several streams in great abundance thus attracting the bears (Maps I-2,I-3,II-2,II-3,II-4). A summary of the fish escapements for the tributaries in this area are listed in Table 16.

Zoning

The Lower Kenai area is zoned essential except for the heavily populated western one-third and areas near the

Sterling highway. A corridor zone is designated for the area north of Skilak lake. This is to connect the benchlands with the Chickaloon River area. Permanent campgrounds are zoned nonessential.

Management Recommendations

Probable conflicts between humans and brown bears within this area are likely in several places. (1) Upper Russian Lake, (2) Aspen flats, (3) Outlet of the Kenai River at Skilak Lake and the Skilak loop area, and (4) Funny River horse trail. Because these 4 areas receive high brown bear use, special consideration to reduce conflicts in these areas is necessary.

Upper Russian Lake receives two runs of red salmon. The southern end of the lake needs to be maintained as undisturbed as possible. The south end of the lake should remain undeveloped so human activity is kept to a minimum. This can be accomplished by prohibiting the construction of new trails or cabins in this area.

The south end of the lake is used by brown bears and bald eagles during the spawning periods. Both species are disturbed by boaters and aircraft. To reduce this disturbance it is recommended that the south half (from Bear Creek, south) of Upper Russian Lake be closed off to float planes and boaters from 15 July to 15 October. Enforcement would be very difficult.

The number of recreationists using the existing trail system should be monitored every five years to note trends in use. An upper limit of recreational use in the area during the salmon spawning period seems to be the only realistic approach to controlling the visitors should they increase dramatically.

Aspen flats is an area frequented by brown bears during the summer. There is a USFS cabin next to the Russian River in this area. Campers that use this cabin must be warned of possible bear encounters. Proper food and garbage storage is crucial to prevent the habituation of brown bears to human food. Relocating the Aspen Flats cabin to an area with less potential for human/bear conflicts should be considered.

Where the Kenai River flows from Skilak Lake, brown bear use is common when silver salmon are spawning. Because this area is in close proximately to both the town of Sterling and the Skilak loop road it is recommended that signs be posted warning people of the possibility of encountering bears there. Construction of new roads or cabins in the area of Torpedo Lake should be prohibited. The Cabins that do exist there should only be used in the winter, spring and summer to reduce conflicts with the bears in the fall.

The Skilak loop area is heavily used by recreationists throughout the summer. Development of the Skilak Loop Wildlife Management Area will increase the potential for bear/human conflicts with both black and brown bears. Sanitation procedures as described in the previous zoning section should be a primary management concern. Bear-proof garbage containers and regular collection is important to avoid attracting bears to this area.

The Funny River horse trail cuts into the primitive wilderness area as the trail nears the Funny River. The potential for conflicts is greatest during a period from June to November. Use of the trail should be monitored for significant increases.

Table 16. Estimated salmon escapements and brown bear use for the Lower Kenai River Area, Kenai Peninsula, Alaska.

Drainage	King Salmon	Red Salmon	Silver Salmon	Pink Salmon	Dog Salmon	Bear Use
Lower Kenai River	*	*	2500	?	0	mod.
Slikok Creek	?	0	?	0	0	low
Beaver Creek	?	?	?	0	0	low
Moose River	few	500	?	0	0	mod.
Funny River	few	0	?	?	0	high
Killey River	8000	0	?	?	0	high
Benjamin Creek	600	0	0	0	0	high
U. Russian Lake	0	60000	2500	0	0	high
Hidden Lake	0	20000	500	0	0	mod.
Jean Creek	0	3000	0	0	0	
TOTAL	8600+	83500+	5500+	?	0	
Average Spawn	Jun.15	Jul.1	Aug.25	Aug.1	Aug.	

? undetermined escapement
* included in the other drainage estimates

Area "E" Upper Kenai River

Description

The Upper Kenai River Drainage includes all the tributaries that are upstream from where the Russian River enters the Kenai River. Because of the amount of human activity around Kenai Lake most of this area is not heavily used by brown bears.

Brown Bear Abundance

The most essential site for brown bears in the Upper Kenai River Area is the South fork of the Snow River. There are three sites where salmon spawn at in this drainage. All three are used by brown bear from July through September.

The area at the south end of Cooper Lake is used by brown bears in the spring. Observations and tracks are frequently seen along the trail, in avalanche chutes and riparian sites.

Brown bear observations and tracks are also seen along the shore of Upper Trail Lake and Trail Creek. This area is used by bears during the red and silver salmon runs. Salmon escapements are given in Table 17.

Zoning

Three essential zones are designated for bears in this area; Trail Creek, Snow River (south fork) and west of Cooper Lake (Maps I-4,I-5,II-4,II-5). Two Corridor zones are designated to maintain travel routes 1) north and south along the east side of the Kenai Mountain range and 2) east and west through the Kenai Mountains south of Kenai Lake.

Management Recommendations

The corridor route south of Kenai Lake is extremely important to allow movement (i.e. dispersal, breeding) between the south fork of the Snow River and the western portion of the peninsula. Protection of the south fork of the Snow River from increased human activity is recommended. Making this a walk-in area may be the best way to insure the brown bear's presence in this drainage. This may be the best brown bear site on the eastern side of the Kenai Mountains because of its juxtaposition with the remote Nellie Juan drainage.

The north shore of Upper Trail Lake is used by brown bear and the impact of the Johnson Pass trail use should be of concern (see Placer River Area).

The Cooper Lake trail is part of the RCR trail system and human use of the trail system should be monitored as described in the executive summary of this document. Signs located at the trailheads, to educate trail users of potential bear encounters and ways to avoid them, are necessary.

Table 17. Estimated salmon escapements and brown bear use for the Upper Kenai River Area, Kenai Peninsula, Alaska.

Drainage	King Salmon	Red Salmon	Silver Salmon	Pink Salmon	Dog Salmon	Bear Use
Juneau Creek	90	few	0	0	0	low
Quartz Creek	?	0	?	0	0	low
Moose Creek	?	5000	0	0	0	low
Trail Creek	0	3500	?	0	0	high
Grant Creek	50	0	?	0	0	low
Ptarmigan Creek	50	40000	0	0	0	low
N. Fork Snow River	0	?	?	0	0	mod.
S. Fork Snow River	0	?	?	0	0	high
Crescent Creek	?	0	0	0	0	mod.
TOTAL	190+	48500+	?	0	0	
Average Spawn	Aug.15	Aug.25				

? undetermined escapement

Area "F" Tustumena Lake

Description

The Tustumena Lake area includes all the tributaries that run into Tustumena lake plus Crooked Creek and the Kasilof River. Most of the Area is considered to be essential to brown bear survival. The Tustumena Area receives large numbers of red and silver salmon (Table 18). This concentration of fish along with the remoteness of most of the area surrounding the Lake provides excellent summer/fall habitat for bears.

Brown Bear Abundance

Brown bears are relatively numerous around Tustumena Lake. They are known to use nearly all the streams there. This area is a southern extension of the Lower Kenai Area and is considered very important bear habitat.

Zoning

All but the most western portion of the Tustumena Area is zoned essential (Maps II-2,II-3,III-2,III-3). The western portion of the area is heavily used by recreationists during the summer and fall. Because the area is designated wilderness by the USFWS, its management as a essential zone should be easier.

Management Recommendations

Recreational boaters on Tustumena Lake should be warned of the dangers of camping at the mouths of the salmon spawning streams during the summer and fall.

The Cooked Creek fishing access is state operated. The area has recently undergone major renovation to provide recreationists with a higher quality facility. Bear-proof dumpsters should be installed to prevent the attraction of bears to the area.

Table 18. Estimated salmon escapements and brown bear use for the Tustumena Lake Area, Kenai Peninsula, Alaska.

Drainage	King Salmon	Red Salmon	Silver Salmon	Pink Salmon	Dog Salmon	Bear Use
Crooked Creek	3000	0	200	?	0	low
Nikolai Creek	0	12500	?	0	0	low
Shantalik Creek	0	5000	?	0	0	low
Bear Creek	0	58000	?	0	0	high
Pipe Creek	0	?	?	0	0	high
Moose Creek	0	17000	?	0	0	high
Indian Creek	0	?	?	0	0	high
Glacier Creek	0	55000	?	0	0	high
Seepage Creek	0	4600	0	0	0	high
Clear Creek	0	1700	0	0	0	mod.
Crystal Creek	0	900	0	0	0	mod.
TOTAL	3000	154700+	200+	?	0	
Average Spawn	Jul.25	Jul.15	Sept.25			

? undetermined escapement

Area "G" Resurrection River

Description

The Resurrection River Area includes tributaries of the river and several other creeks that flow into Resurrection Bay. Kenai Fjords National Park land and USFS land meet at Resurrection River. Most of this area however is privately owned. Salmon are abundant in the area (Table 19).

Brown Bear Abundance

Brown bear use of the this area is limited to a few sites (Maps II-4,II-5,III-4). The area around Bear Lake receives a moderate amount of use by brown bears. Most of the use is in the fall when silver salmon are present and human activity is lower.

At the headwaters of the Resurrection River, upstream from Boulder Creek, bear use is also considered moderate. It is not known how much of the Resurrection drainage is used by brown bears in the fall but the numbers of silver salmon that spawn are thought to be high.

Zoning

An area near the headwaters of the Resurrection River is zoned essential. The area near Bear Lake is zoned as secondary. Part of the corridor zone to the south of Kenai Lake is located in this area and includes Lost Lake.

Management Recommendations

Bear Lake has the potential for bear/human conflicts because the lake is very close to a subdivision. It is recommended that proper garbage disposal is practiced to avoid problems with bears.

The headwaters of the Resurrection River should be classified as an essential zone. A female brown bear denned at the head of Summit Creek for three consecutive years which is testimony to the areas importance.

Park Service should be informed about the potential dangers of brown bear along the river above Boulder Creek so they can inform visitors to the park. From available data, this is the only area in the national park that conflicts with brown bears might occur.

Table 19. Estimated salmon escapements and brown bear use for the Resurrection River Area, Kenai Peninsula, Alaska.

Drainage	King Salmon	Red Salmon	Silver Salmon	Pink Salmon	Dog Salmon	Bear Use
Resurrection River	?	0	34000	?	0	mod.
Grouse Creek	0	150	500	?	0	low
Bear Lake	0	500	3500	0	0	low
Salmon Lake	0	?	?	?	0	low
Spring Creek	0	?	?	300	500	low
Tonsina Creek	0	0	?	4000	4000	low
TOTAL	?	650+	38000+	4300+	4500	
Average Spawn		Aug.1	Oct.14	Aug.28		

? undetermined escapement

Area "H" Nellie Juan

Description

Very little is known about the Nellie Juan Area with respect to brown bear use. Salmon spawning sites are abundant throughout the coastal fjords and Islands, but bears are not thought to inhabit the area in great numbers. There is a travel corridor that connects the interior peninsula with Kings Bay (Maps I-5,I-6,II-5,II-6,III-5). The Nellie Juan River drainage is connected to the south fork of the Snow River.

Bear Abundance

Brown bears are seen in the Paradise Valley and the Nellie Juan Drainage during the summer. Although observations are not common, the area is not commonly visited by large numbers of people. Therefore abundance is unknown.

Zoning

A portion of this area is zoned essential because of its position with respect to the Snow River and the interior of the peninsula. This area is very important to the bear population because it represents an area east of the Kenai Mountains that can support bears.

Management Recommendations

A portion of the Nellie Juan Area is presently protected under the USFS wilderness classification. Because very little is known about its importance to the bear population it should be managed as essential until proven otherwise.

Area "I" Anchor River

Description

The Anchor River Area is an area extending from Clam Gulch, south along the coast to Homer, to the north eastern end of Kachemak Bay and then back to Clam Gulch in a line that includes the headwaters of Deep Creek and the Ninilchik River. This area is predominately state and private land (Maps II-1,II-2,III-1,III-2). The Anchor River area is made up several major drainages. These are the Ninilchik River, Deep Creek, Stariski Creek, Chakok River and Anchor River. These drainages provide spawning habitat for king and silver salmon. Because these species are the most abundant they are of greatest importance to brown bear in this area (Table 20).

Problems arising between brown bears and people are present in this area because of the amount of human activity occurring here during the summer and fall. An increase in human activity will result in the loss of essential brown bear habitat.

Brown Bear Abundance

The Anchor River - Spawning occurs into the headwaters of the Anchor with most occurring below Beaver Flats. Bears are using the river to fish as early as July and possibly earlier. Foot access to the middle section of the South

Fork Anchor River can be gained by the North Fork loop road.

The Chakok River - We can only assume that brown bear use portions of the Chakok during the salmon runs. With the large numbers of silver salmon that spawn in this river some brown bear use is likely.

Deep Creek - Spawning occurs along a large portion of the creek with the majority near the junction of the north fork and the middle fork of Deep Creek. There was heavy use by bears along the creek near the junction of the north fork and the middle fork by brown bear. Using track measurements, 11 individual brown bears were estimated to be using the area during the ground survey. Brown bear use is greatest during July when kings salmon are present, however, the bears continue to use the area in the fall when silver salmon spawn there.

Ninilchik River - Brown bear use is moderate to heavy in July. The lower portions of the Ninilchik are fished heavily by people. However, ADF&G allows fishing only on these lower portions to protect spawning habitat upstream.

Zoning

The Headwaters of these rivers and creeks are considered essential and are zoned accordingly. Some areas are secondary or nonessential as human settlements are spread in a horseshoe shape around this area. Because the area is mostly state and private land, management of this area will be extremely difficult to control.

Management Recommendations

Approximately 50 cabins are located on the ridges above the north fork of Deep Creek and many others are located on the middle and south fork and the Anchor River (Fig.26). Numerous off-road-vehicle (ORV) trails are also located at the upper end of this drainage. Road-vehicle access is most evident along the river below South Beaver Creek and appears to be used by fisherman.

The cabins which are located around the headwaters of Deep Creek and the Anchor River pose a problem to this essential area. An essential zoning recommends that no motorized vehicles are used, roads are not built and new cabins should not be constructed. This ideal is not realistic in this area because state has allowed the cabins to become solidly established in the area. Because of the area's importance to brown bear this subdivision could act as a bear "population sink", attracting bears to conflicts. Therefore, it is important to manage this area to minimize negative impacts and avoid as many conflicts as possible. Recommendations are:

1) Disposal of garbage should be monitored by the state to be sure open pit dumps are not being created.

2) Establish ORV corridors that would consolidate and minimize effects on wildlife.

3) There should be critical review of applications for grazing leases.

4) Stocking rates should be established for domestic animal use or grazing on state land.

5) Disposal of state land to private individuals should be discouraged. Approximately 75-80 thousands acres of state land is in this area.

6) Legislative designation of the Deep Creek and Anchor River drainages as Wildlife Critical Habitat Areas should be proposed.

Table 20. Estimated salmon escapements and brown bear use for the Anchor River Area, Kenai Peninsula, Alaska.

Drainage	King Salmon	Red Salmon	Silver Salmon	Pink Salmon	Dog Salmon	Bear Use
Ninilchik River	2000	0	?	0	0	high
Deep Creek	1000	0	?	0	0	high
Stariski River	2000	0	?	0	0	low
Chakok River	2000	0	?	0	0	mod.
Anchor River	2300	0	?	0	0	high
TOTAL	9300	0	?	0	0	
Average Spawn	Jul.14		Sep.14			

? undetermined escapement

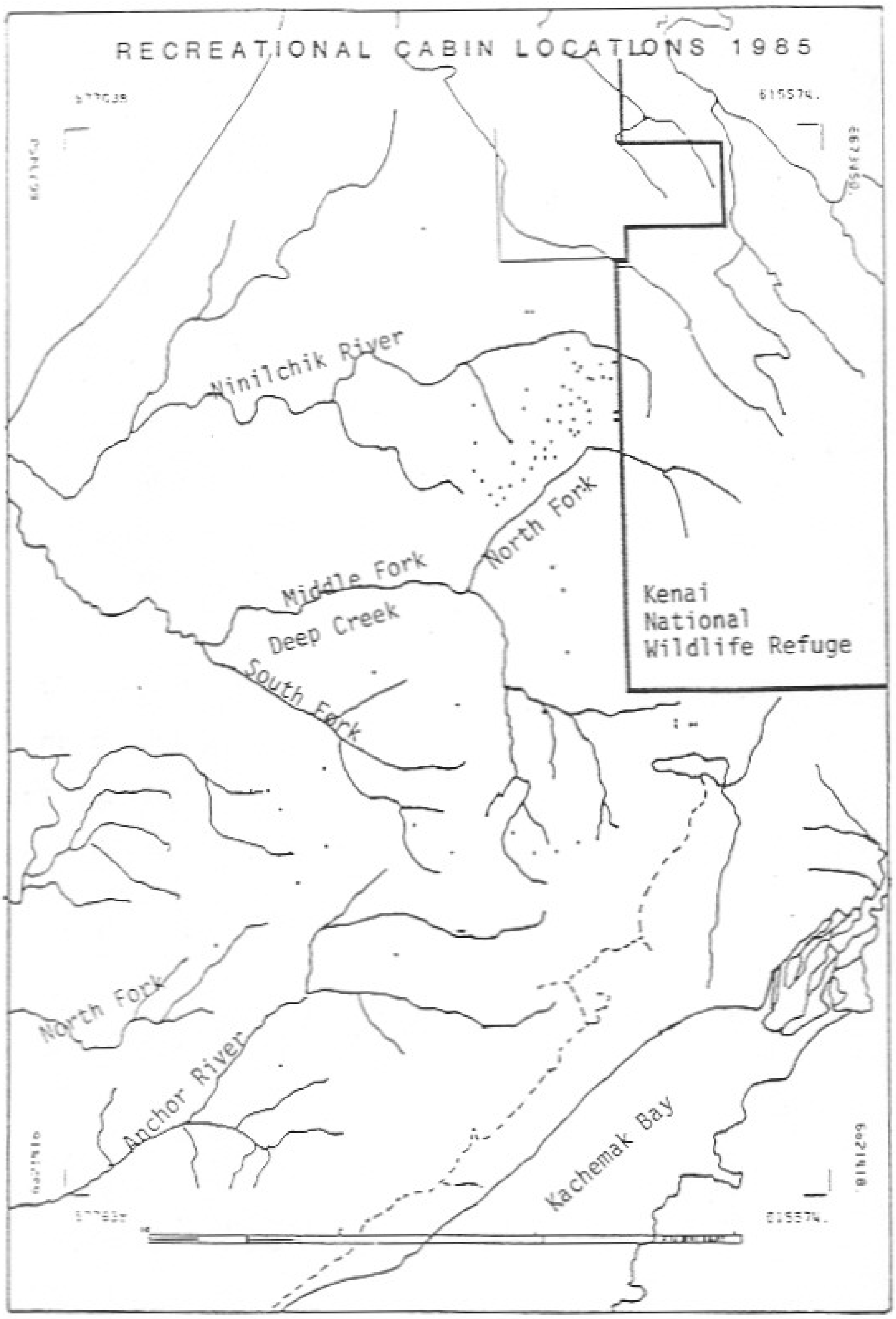


Figure 26. Recreational cabin locations in the Deep Creek-Anchor River areas of the Kenai Peninsula, Alaska, registered with the state as of 1985.

Area "J" Fox River

Description

This area includes Sheep Creek, Clearwater Slough, and the Fox River. The area receives both red and silver salmon runs (Table 21). The lower portion of the Fox River receives extensive human use and the lower valley supports about 60 permanent residents in the village of Delina. ORV trails and the river bed provide access as far upstream as Clearwater Slough.

Brown Bear Abundance

Brown bear use occurs along the Fox River, but is considered moderate to high compared to other areas on the peninsula. The portion of the Fox River, from Sheep Creek upstream, is used more often by bears; bear use below Sheep Creek also occur.

Zoning

The Fox River area is an important extension of the best bear habitat on the Peninsula. Therefore, much of this area is zoned essential (Maps III-2,III-3).

Management Recommendations

The use of motorized boats and ORV's along the Fox River upstream from the mouth of Sheep Creek should be prohibited from late June until November.

The settlements at the mouth of the Fox River should practice proper garbage disposal.

An area of particular concern is the grazing lease located in the lower fox valley on state land. Stocking rates of domestic animals should be set and enforced by the state to minimize negative impacts. Agricultural developments such as hayfields and ranch construction should be prohibited.

Table 21. Estimated salmon escapements and brown bear use for the Fox River Area, Kenai Peninsula, Alaska.

Drainage	King Salmon	Red Salmon	Silver Salmon	Pink Salmon	Dog Salmon	Bear Use
Fox River	0	900	?	0	0	mod.
Clearwater Slough	0	?	1000	0	0	mod.
Sheep Creek	0	?	?	0	0	mod.
TOTAL	0	900+	1000+	0	0	
Average Spawn		Jul.14	Aug.14			

? undetermined escapement

Area "K" Fjords

Descriptions

This area includes most of Kenai Fjords National Park (Maps II-4,III-3,III-4). Brown bear use in this area is thought to be minimal. The Harding Ice field separates this area from interior Kenai Peninsula which probably makes travel between the areas rare. Therefore, the area is not considered essential for the Kenai population because movement of individuals from fjords to the interior is unlikely.

Brown Bear Abundance

The abundance of brown bear is thought to be very low.

Zoning

The area is managed by the National Park Service which does not permit sport/subsistence hunting, trapping, or commercial development.

Management Recommendations

The NPS only needs to consider management of brown bear in the Resurrection River Area.

Area "L" Seldovia

Description

The Seldovia area is known to have brown bears existing in it (Maps III-2,III-3,IV-1,IV-2,IV-3). However, not enough is known about movements from this area to the peninsula's interior. Bears could move from Kachemak Bay State Park to the interior of the peninsula. More information is needed about that area before we can properly advise management.

Brown Bear Abundance

Several brown bear sighting have been reported of in this area although none were recorded by the study team.

Zoning

No zone was applied to this area because of the lack of brown bear information.

Management Recommendations

State employees that work at the state park should be able to offer help in assessing this area for brown bear management.

Zoning and Tenure Maps

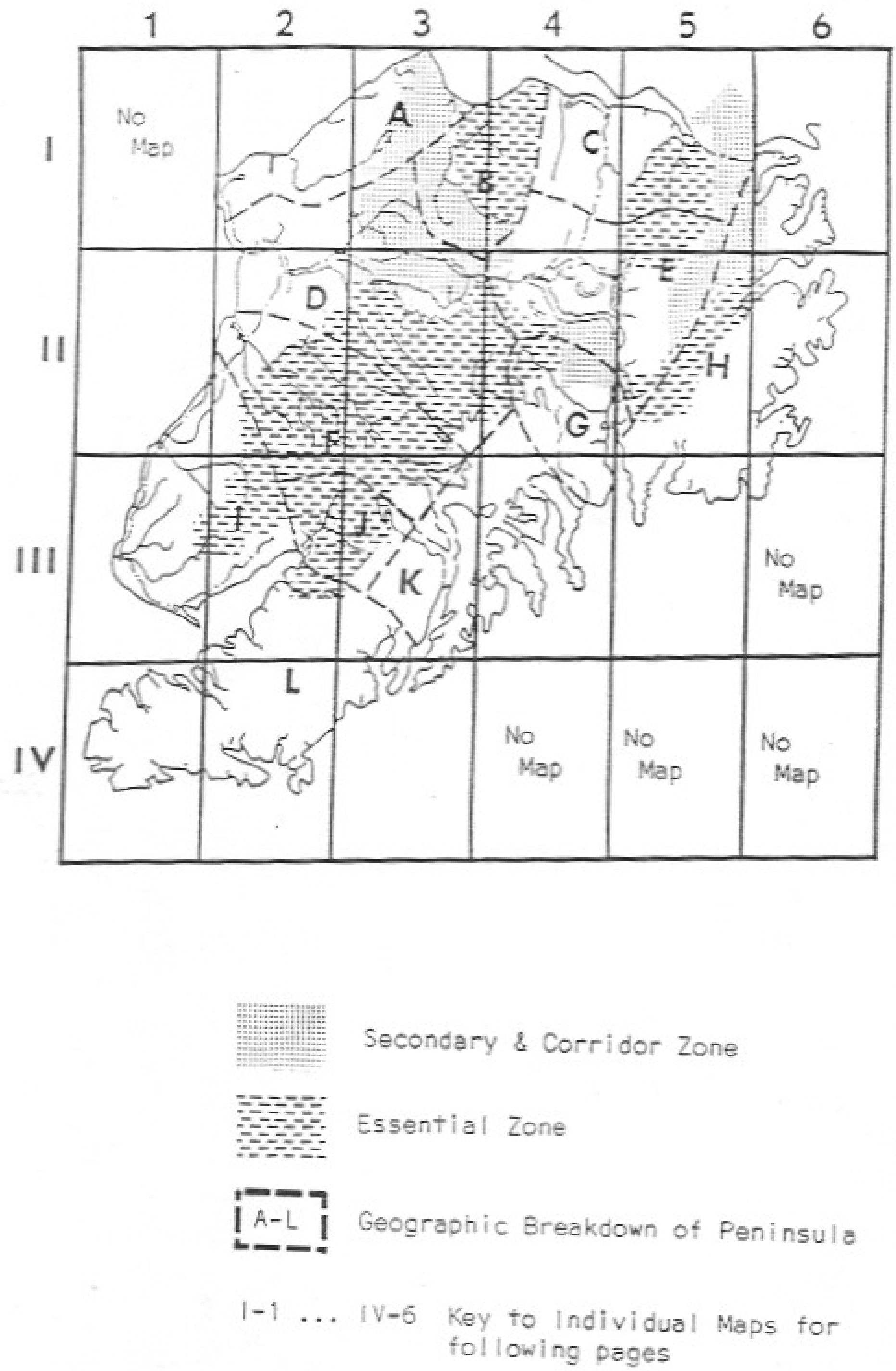


Figure 25. Key to the maps of the Kenai Peninsula, Alaska, showing geographical areas, land tenure and zoning.

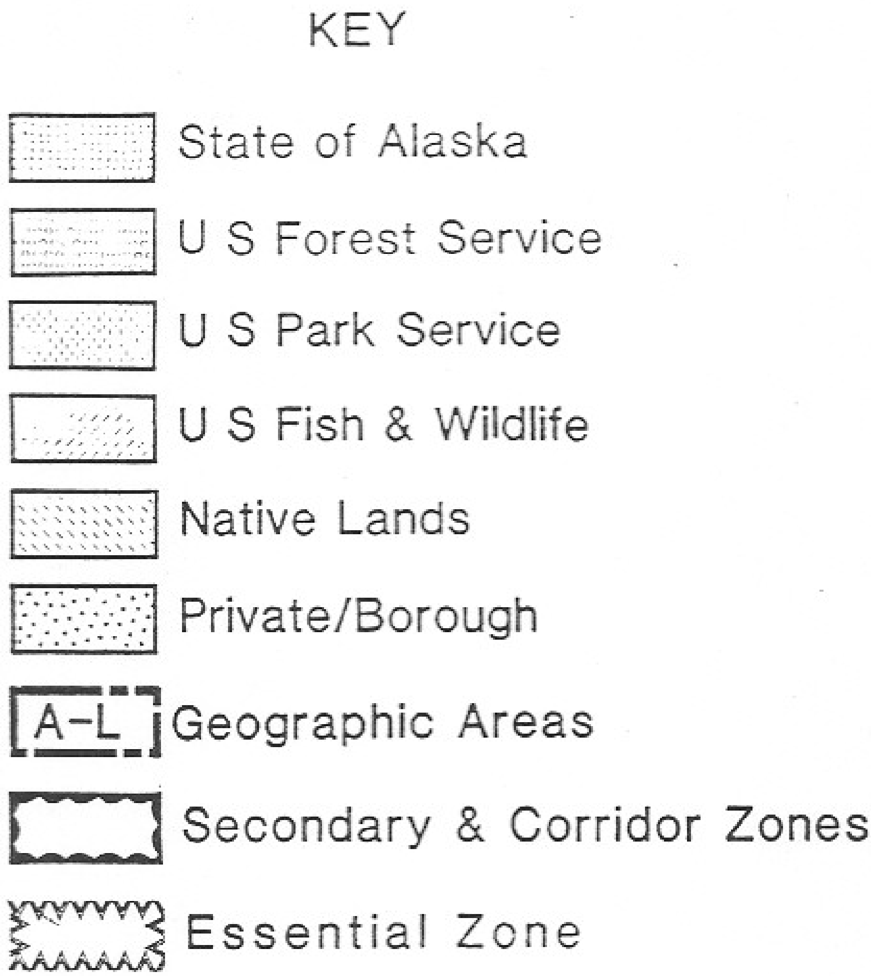
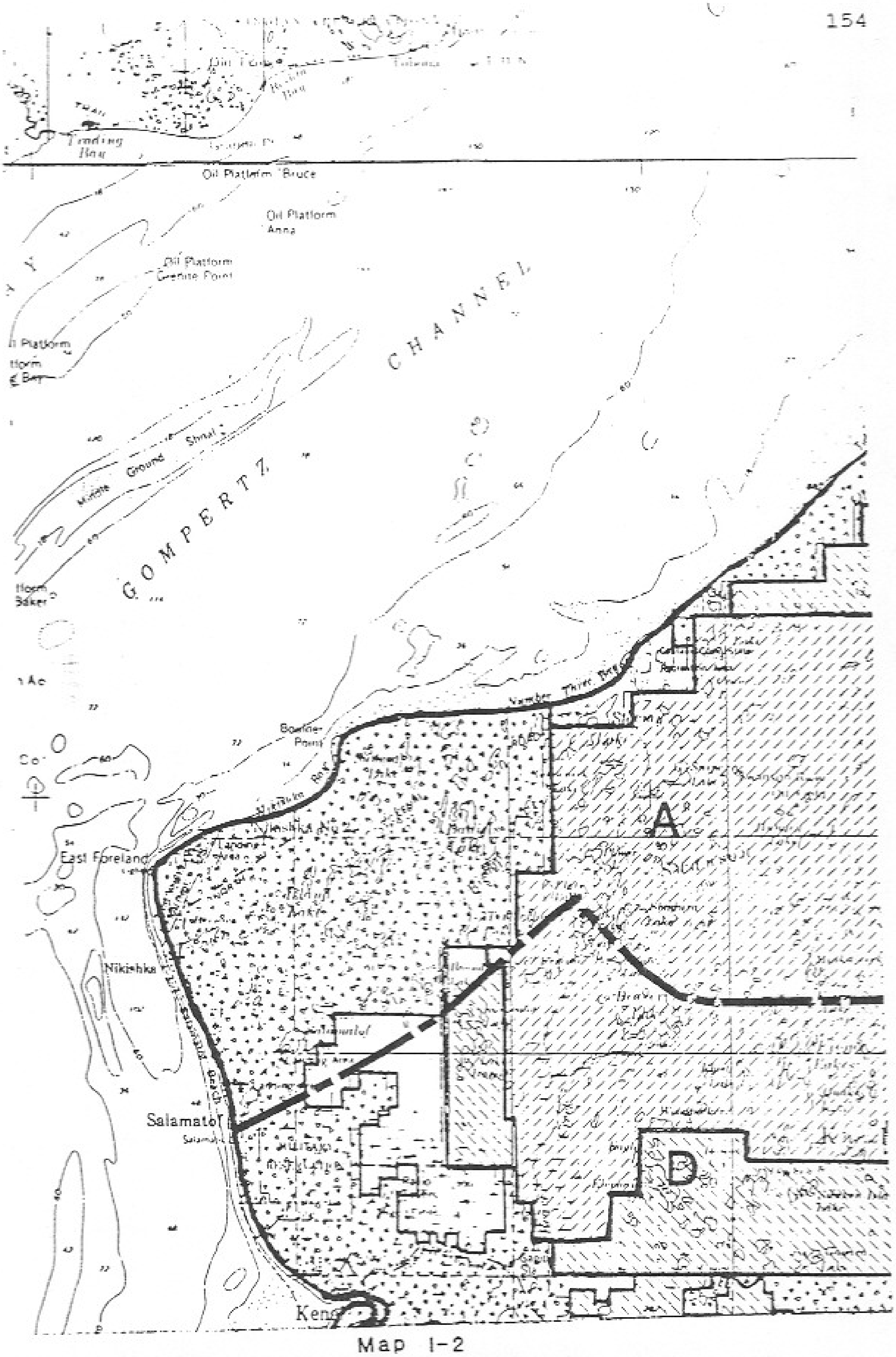
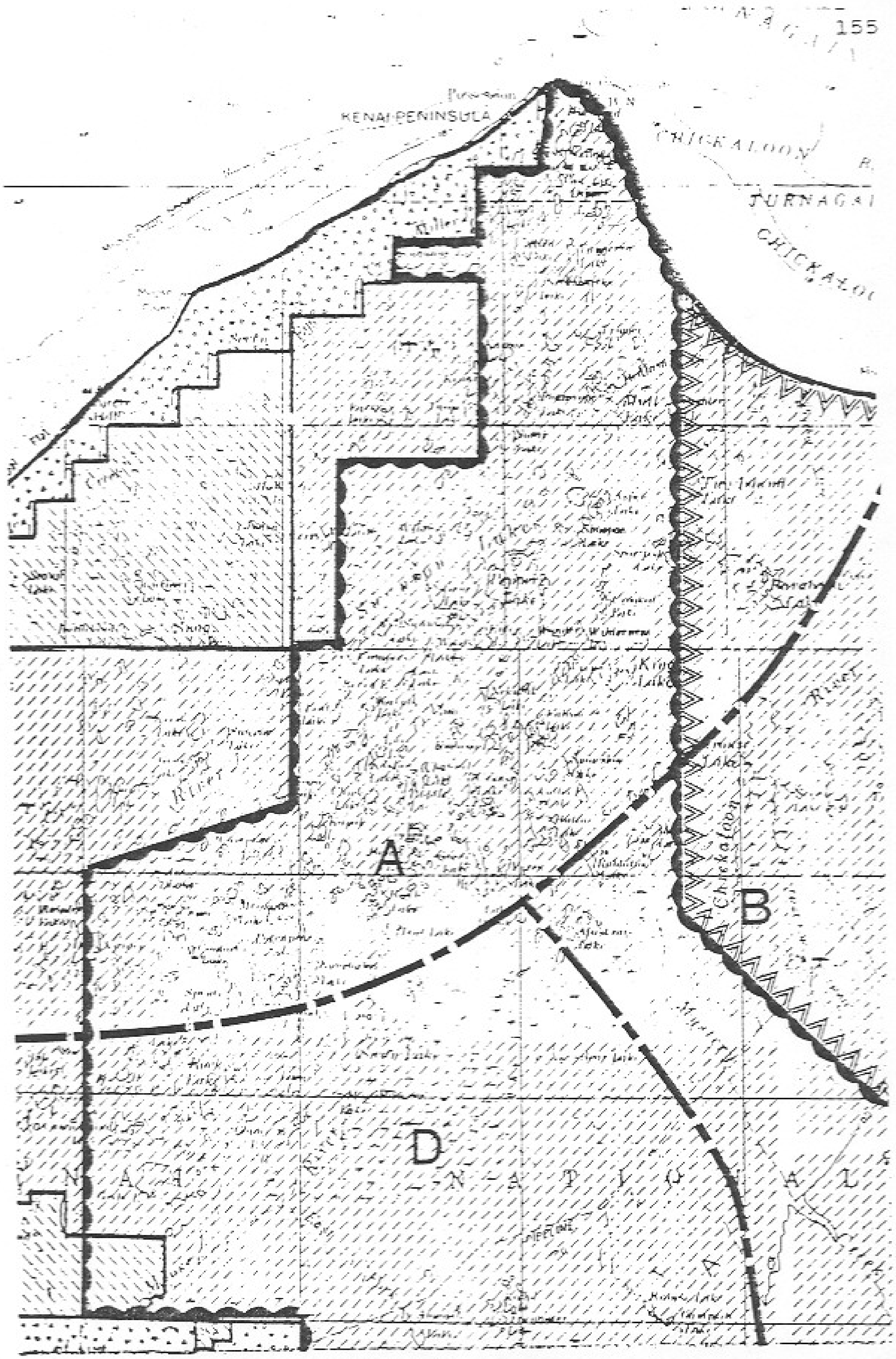


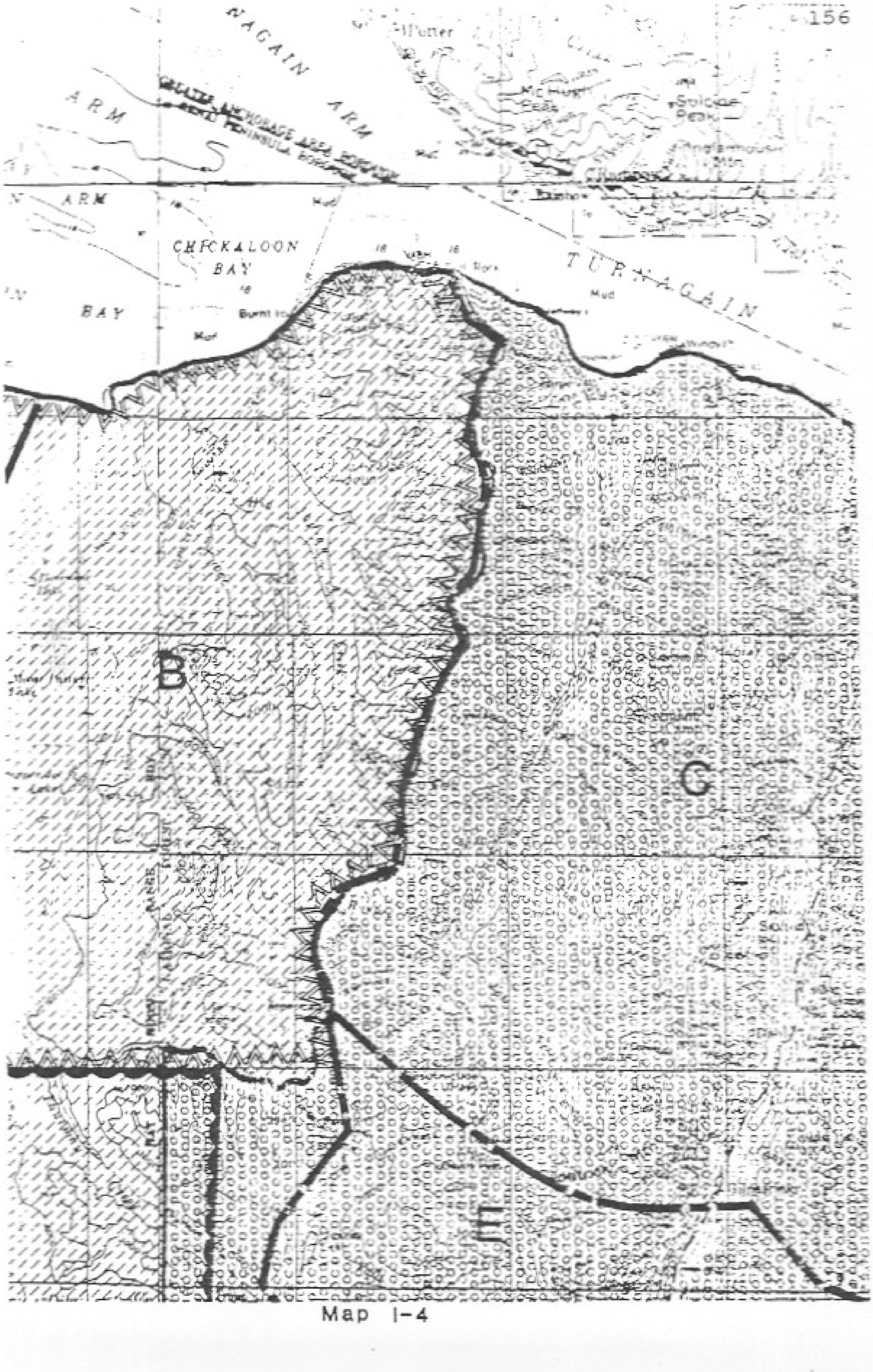
Figure 25a. Key to maps continued.


Trading Bay
Oil Platform Bruce
Oil Platform Anna
Oil Platform Granite Point
CHANNEL
Middle Ground Shoal
GOMPERTZ
Bakeer
Boulder Point
East Foreland
Nikishka
Salamatof
A
D

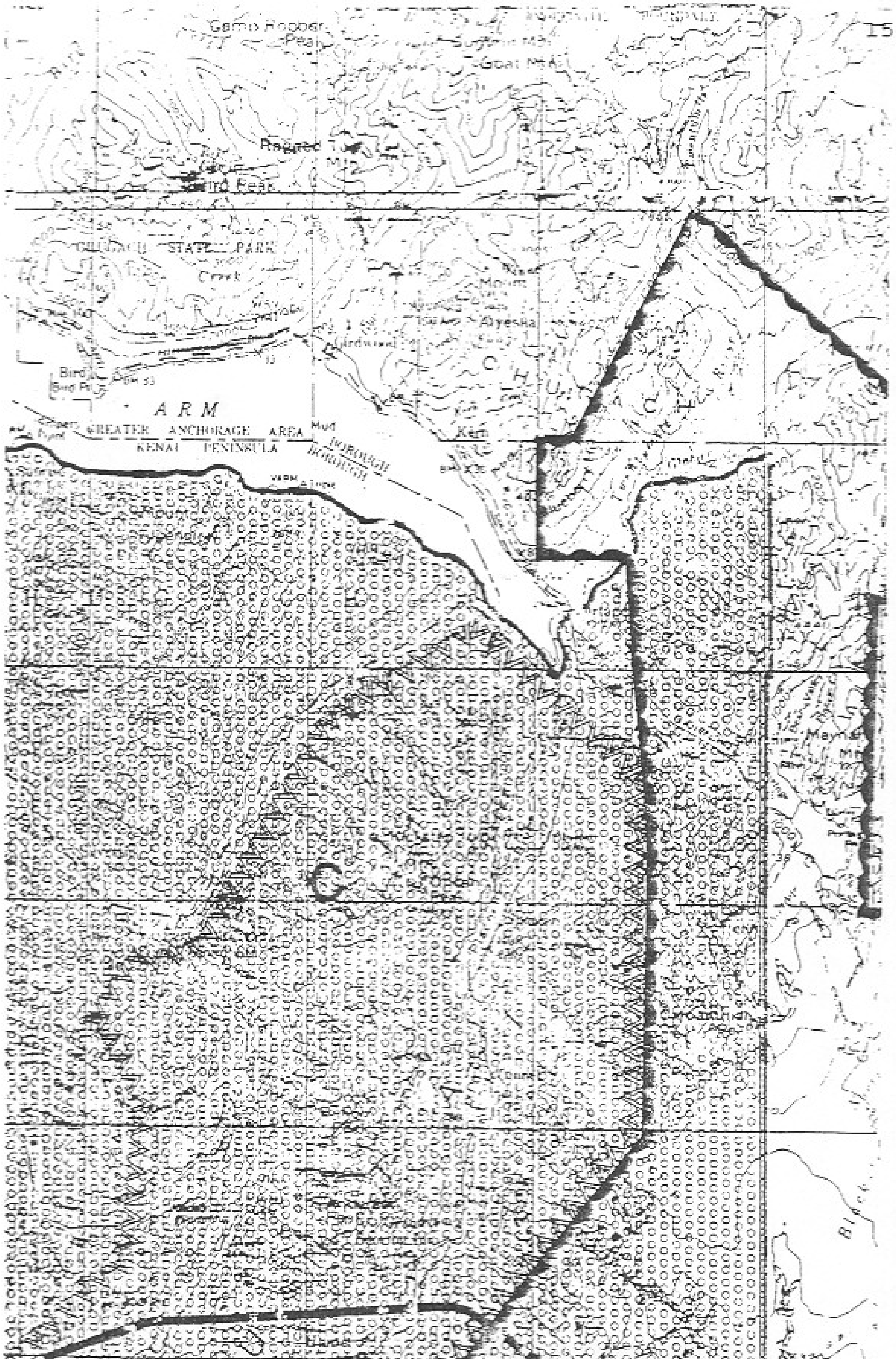
Map I-2


KENAI PENINSULA
CHICKALOON
TURNAGAIN
A
B
D
N A T I O N A L
Chickaloon
King Lake

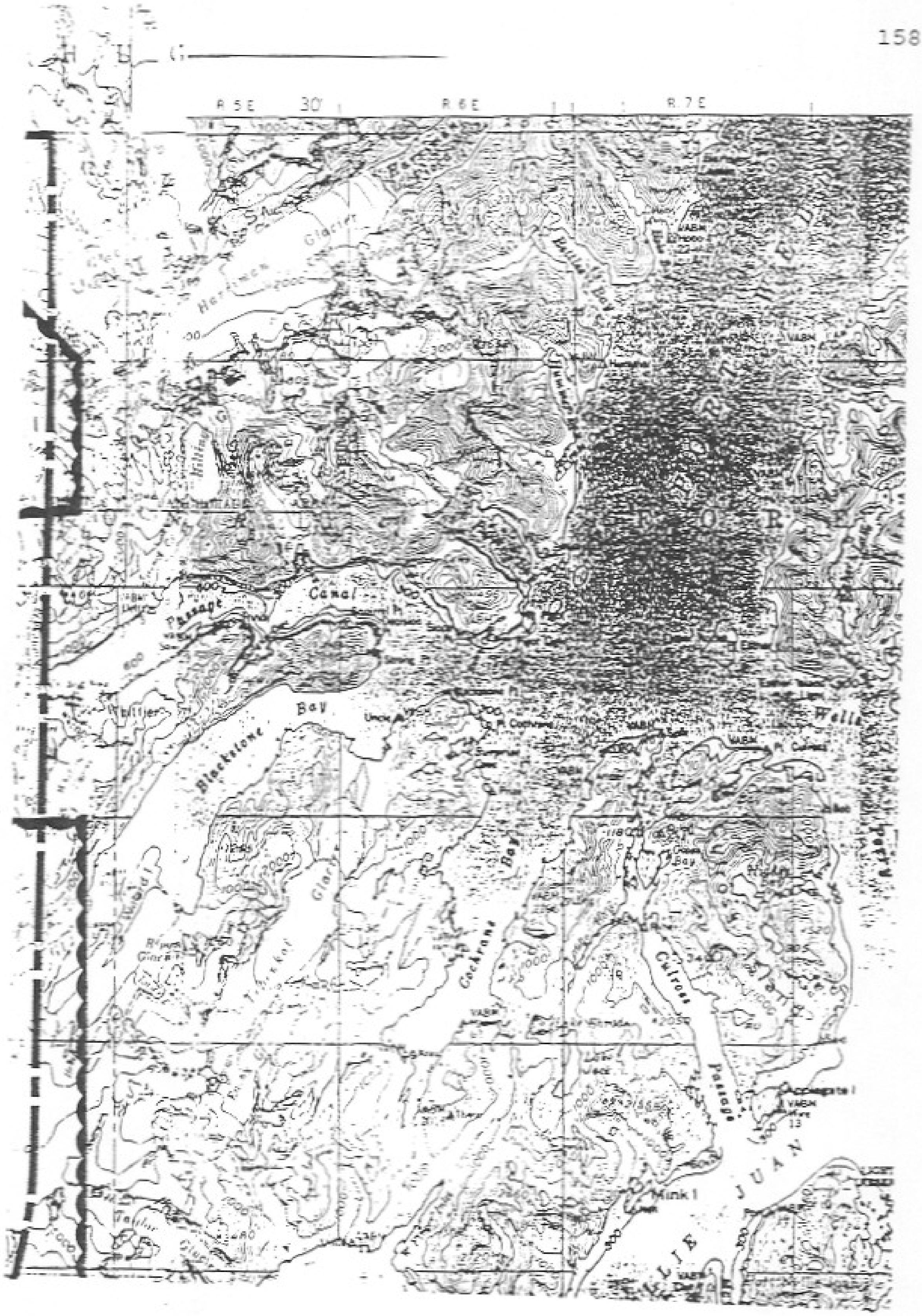
Map I-3


NAGAIN
ARM
ARM
GREATER ANCHORAGE AREA BOROUGH
KENAI PENINSULA BOROUGH
McHugh Peak
Suicide Peak
ARM
CHICKALOON
BAY
BAY
TURNAGAIN
Mud
B
C
E

Map I-4

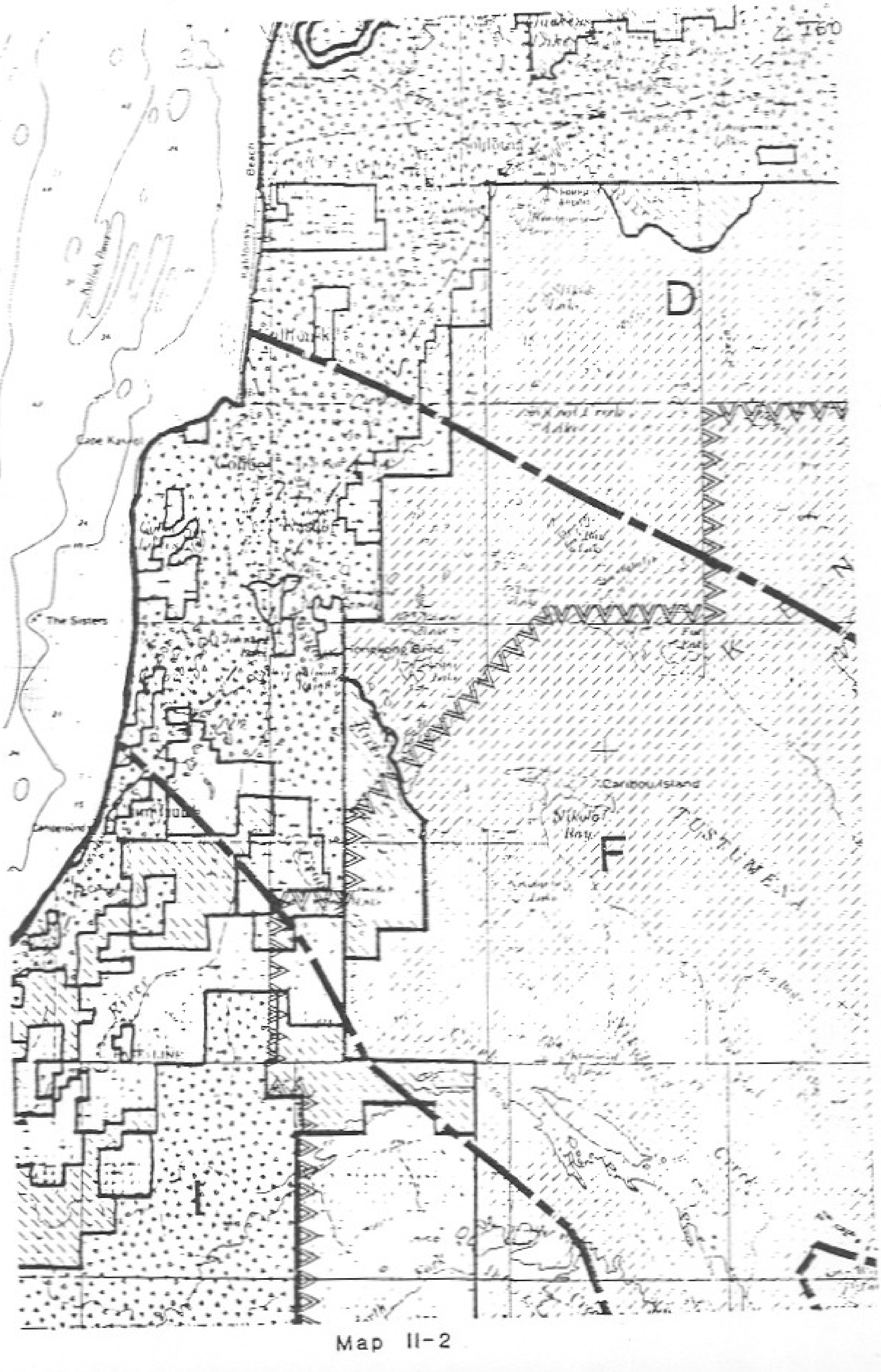

Camp Robber Peak
Goat Mtn
Ragged Top Mtn
Bird Peak
CHUGACH STATE PARK
Alyeska
Girdwood
Bird
Bird Pt
ARM
GREATER ANCHORAGE AREA
KENAI PENINSULA
BOROUGH
BOROUGH

Map I-5

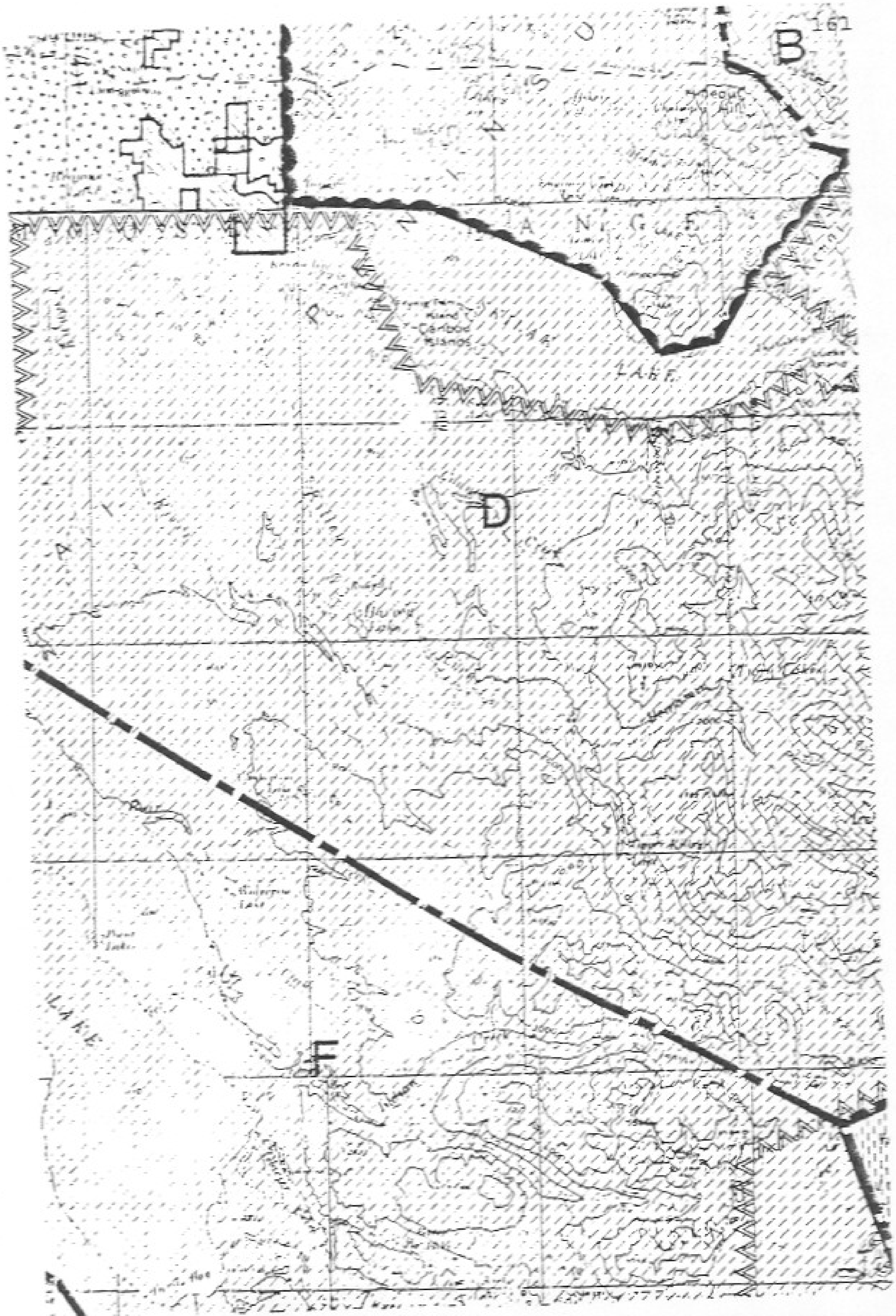

R 5 E
30'
R 6 E
R 7 E
Harriman
Glacier
Canal
Passage
Whittier
Blackstone
Bay
Cochrane
Bay
Culross
Passage
Mink I
Applegate I
Wells
Perry
JUAN

Map I-6

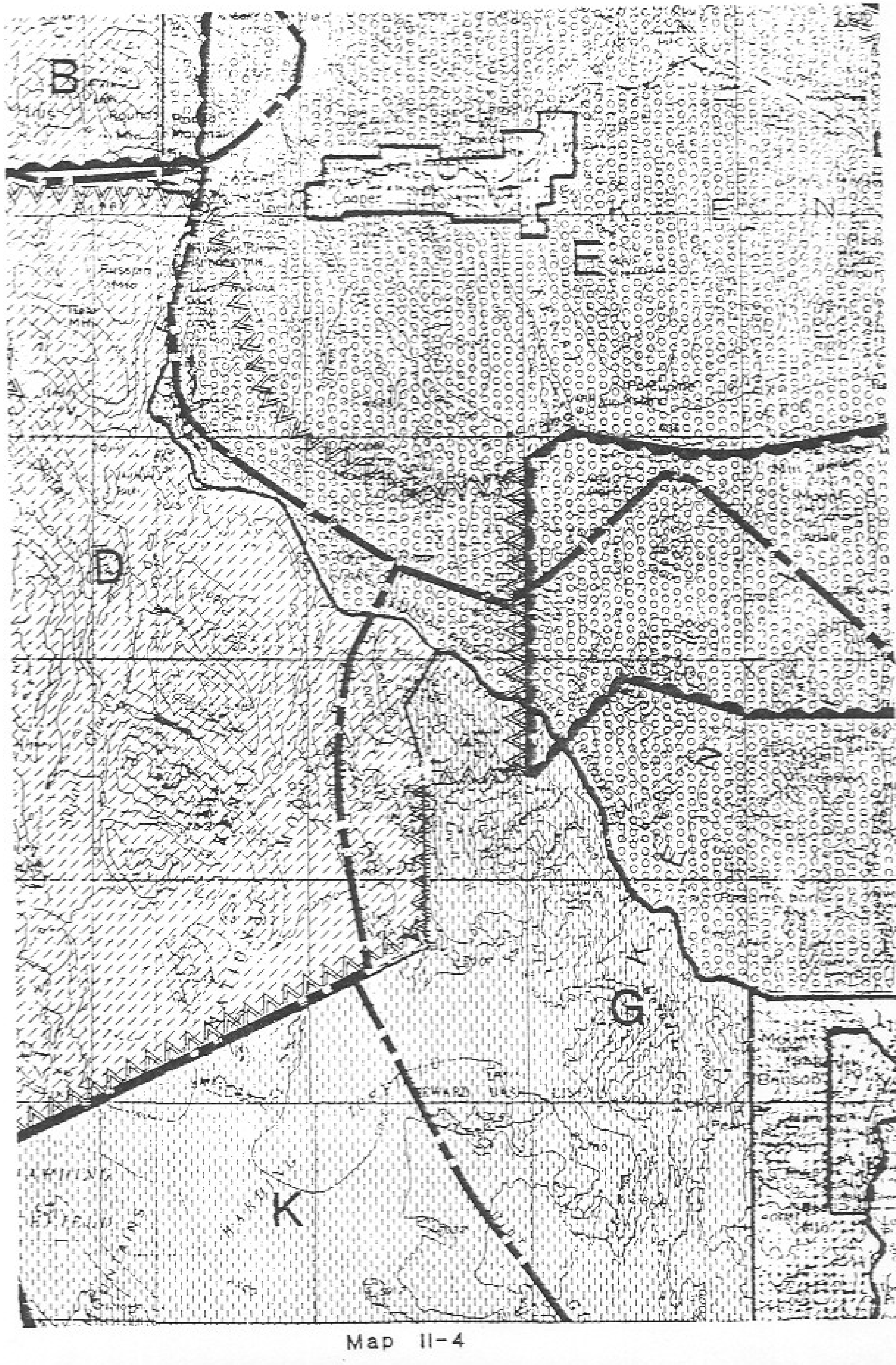
Map II-1



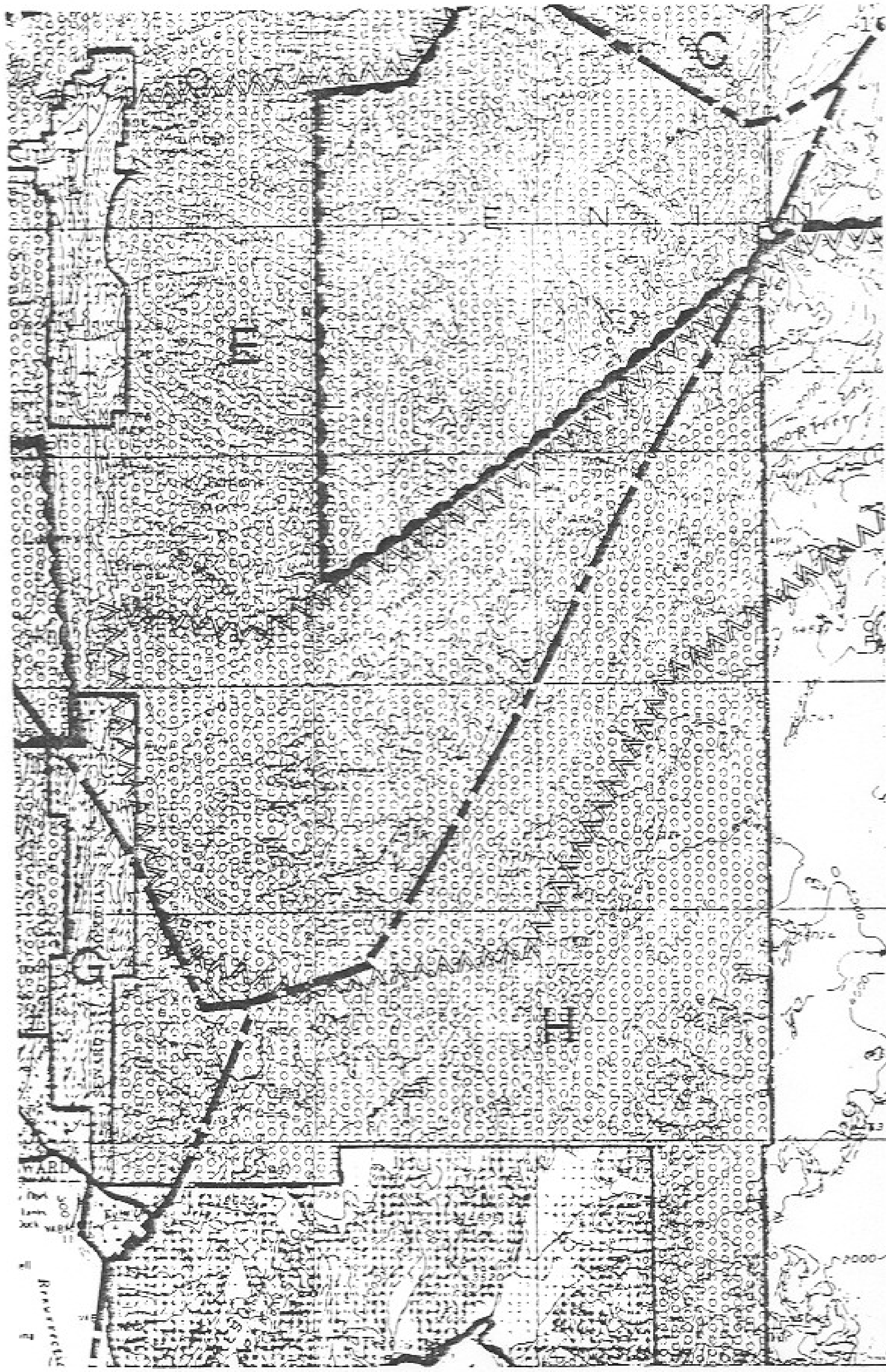
Map II-2



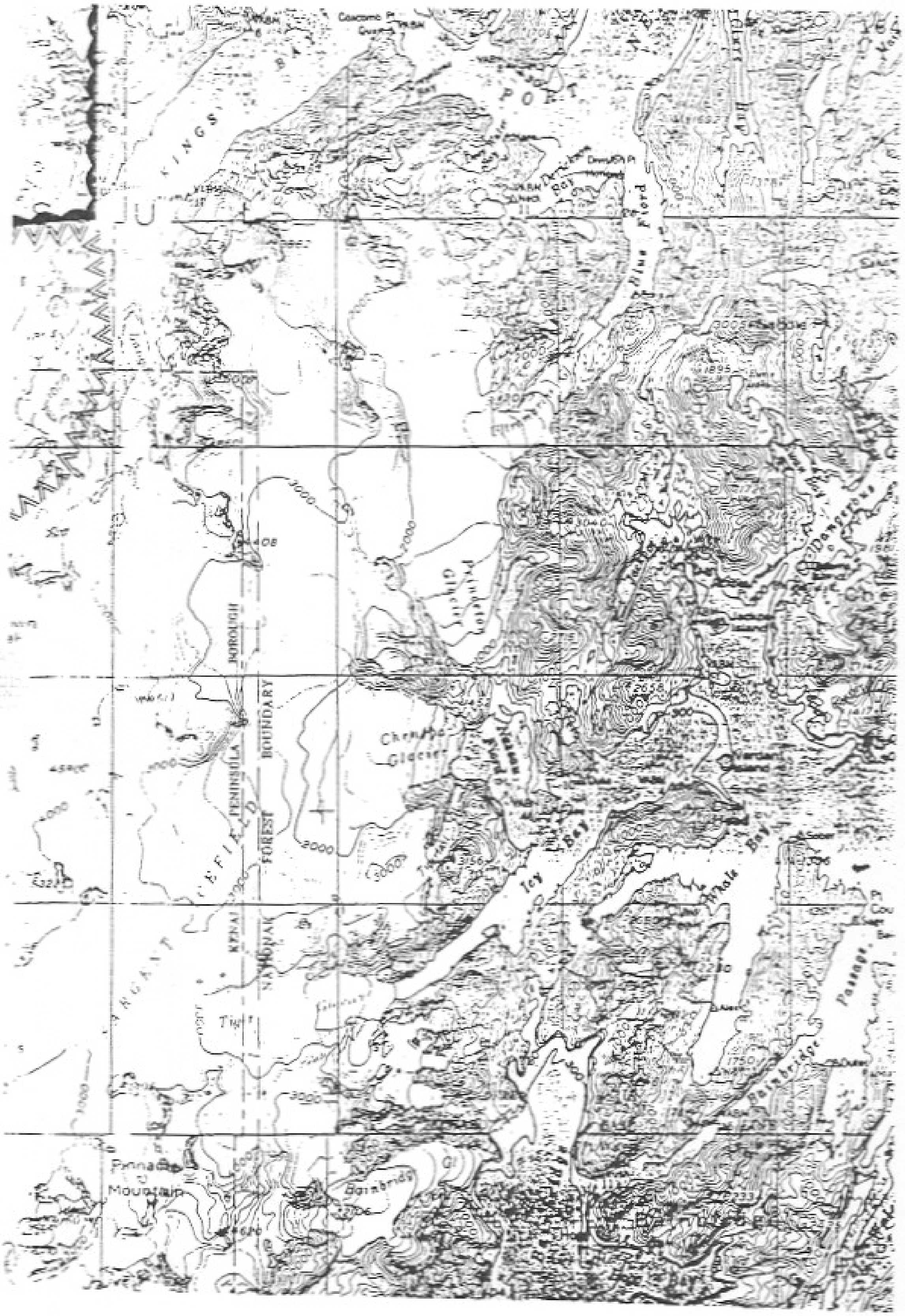
Map II-3



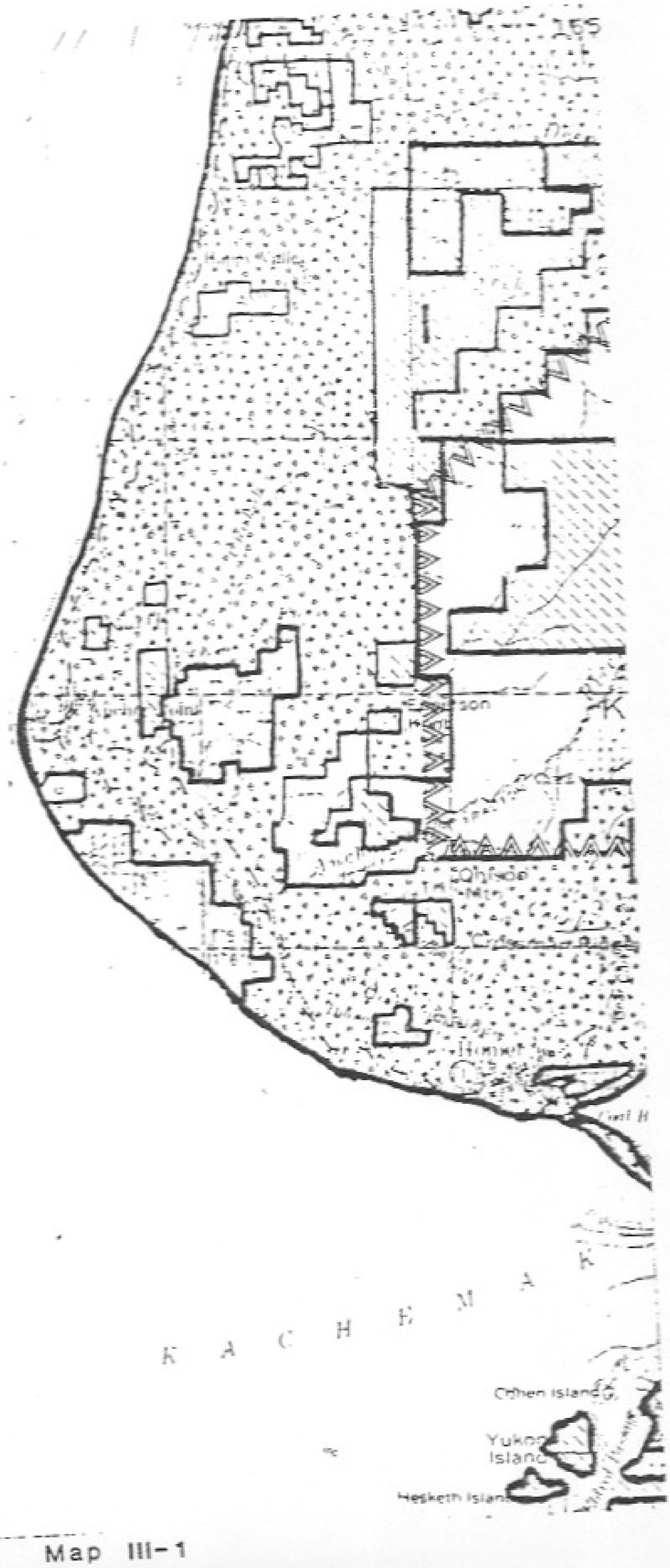
Map II-4



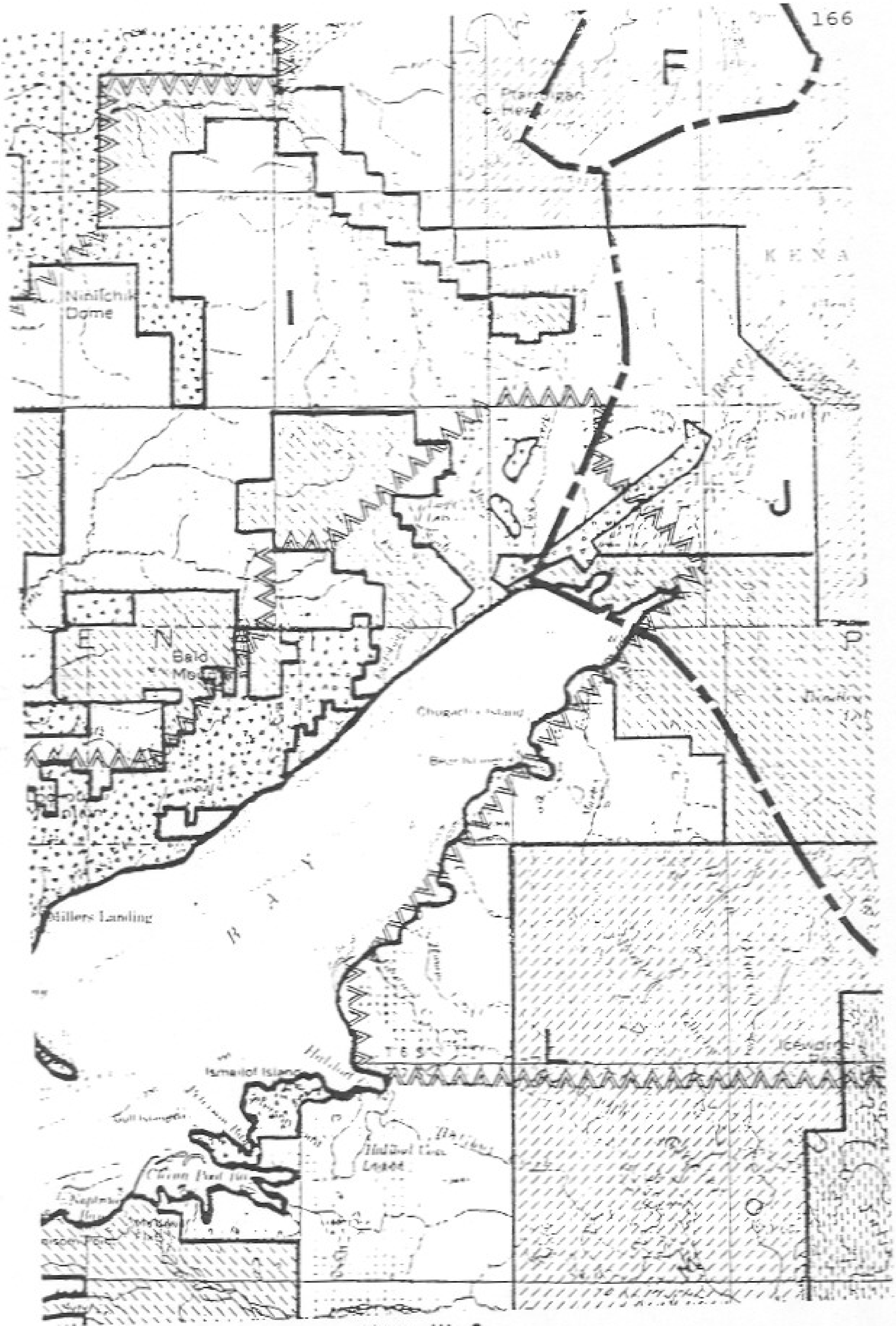
Map II-5


KINGS BAY
PORT
Blue Fiord
Paradise Glacier
Chernof Glacier
Nassau Fiord
Icy Bay
Whale Bay
Bainbridge Passage
Bainbridge Gl
Pinnacle Mountain
KENAI PENINSULA BOROUGH
NATIONAL FOREST BOUNDARY

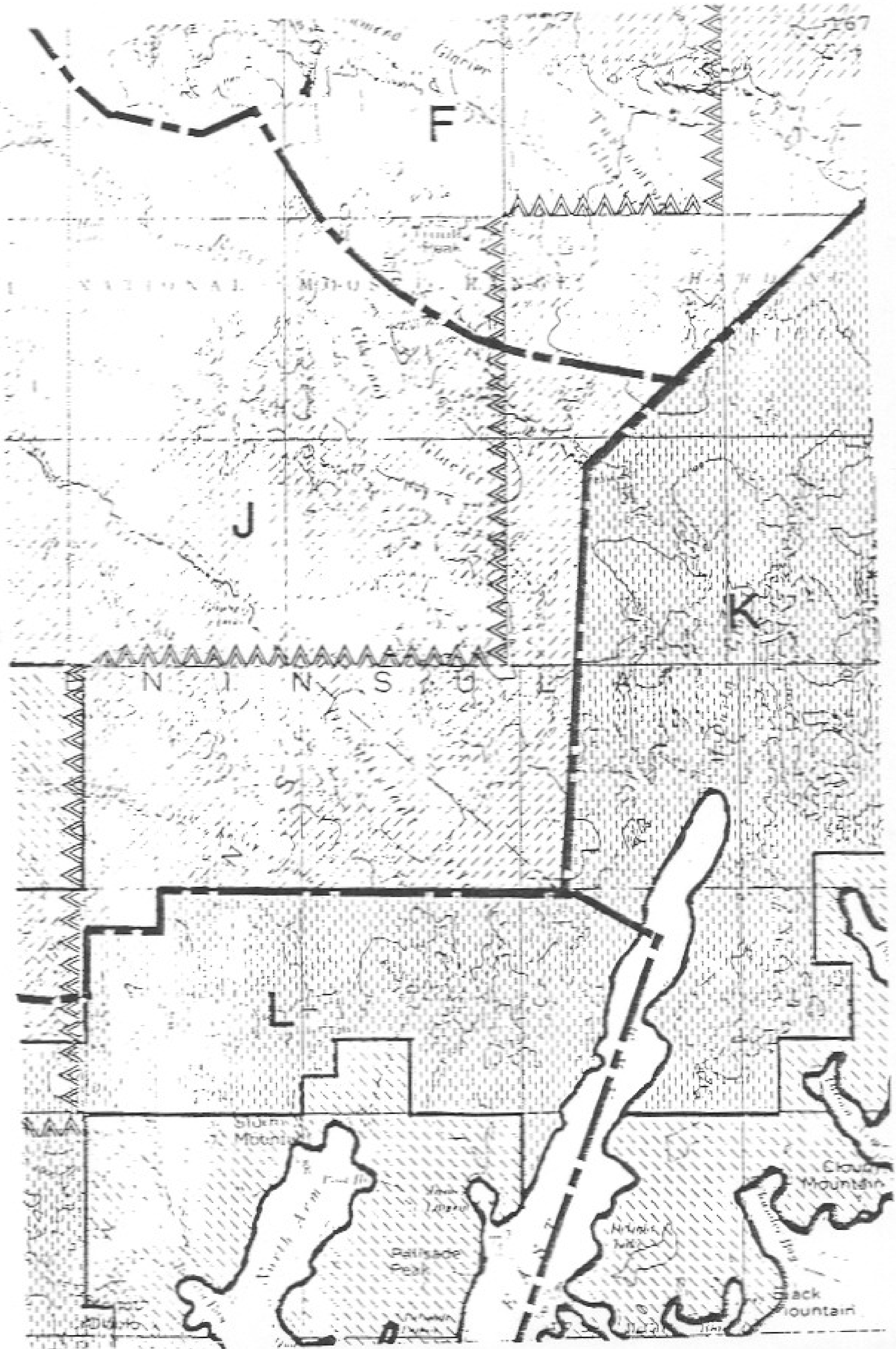
Map II-6


Emerson
Ohlson
Mtn
Homer
K A C H E M A K
Cohen Island
Yukon
Island
Hesketh Island

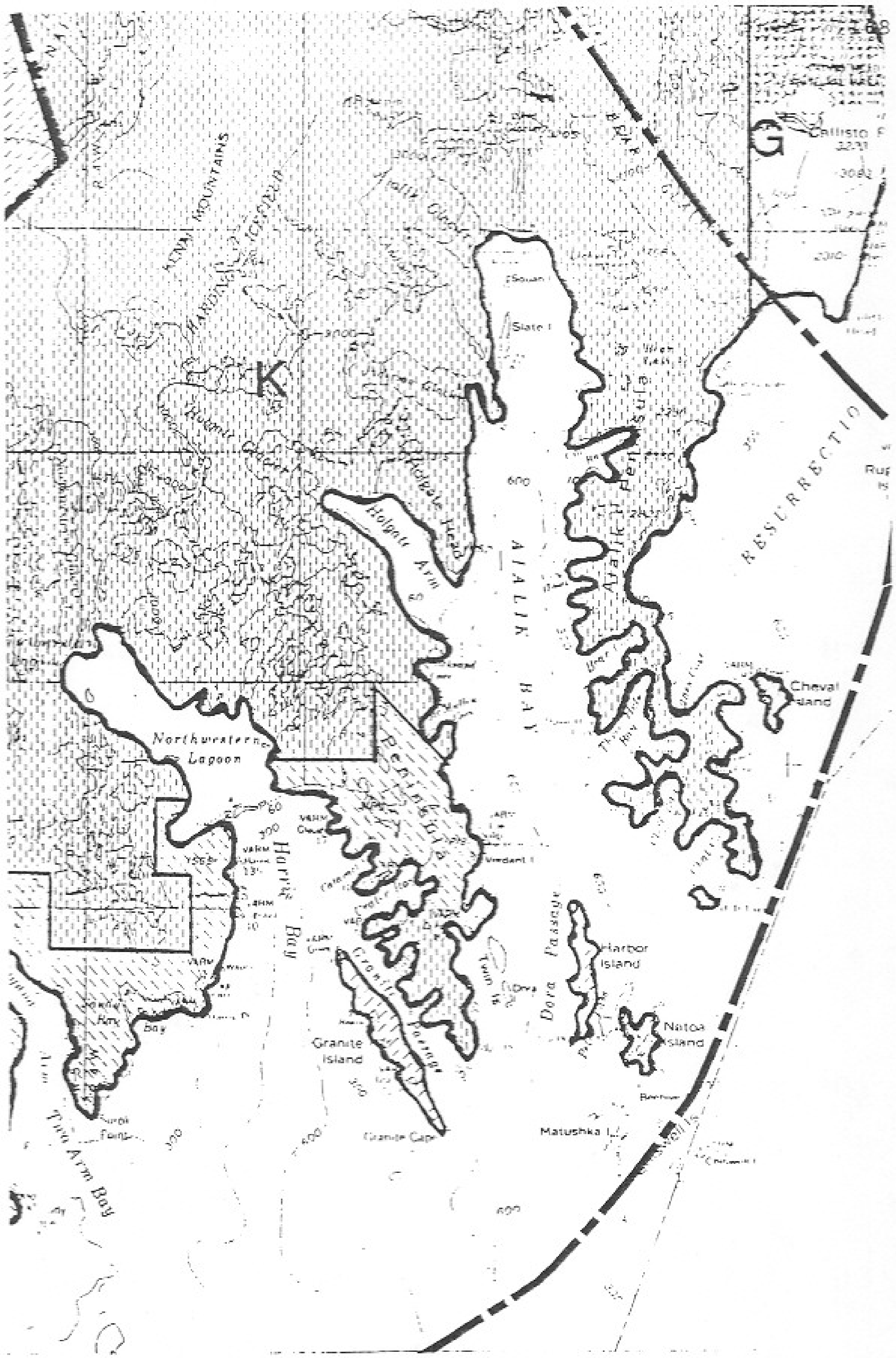
Map III-1


F
I
J
E
N
L
Q
Ninilchik Dome
Bald Mountain
Millers Landing
Chugach Island
Ismailof Island
K E N A

Map III-2

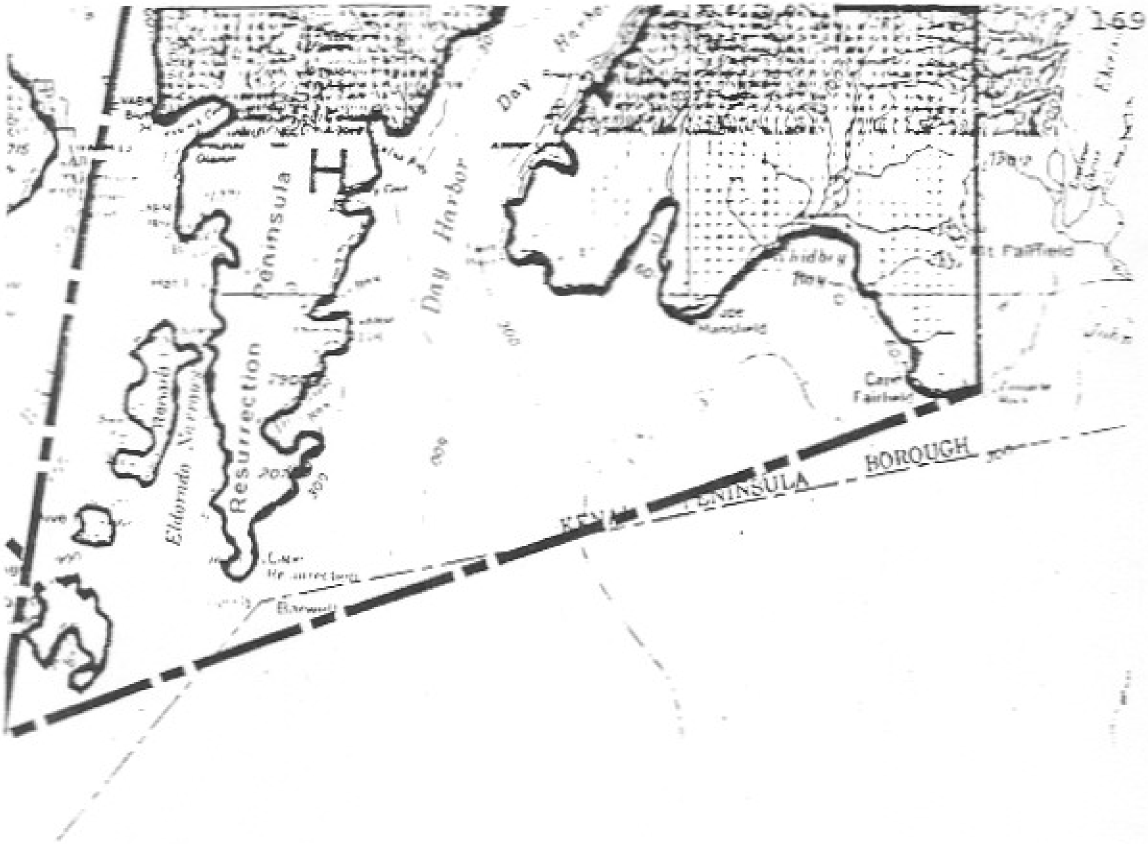

F
J
K
L
NATIONAL MOOSE RANGE
N I N S U L A
Palisade Peak
Black Mountain

Map III-3

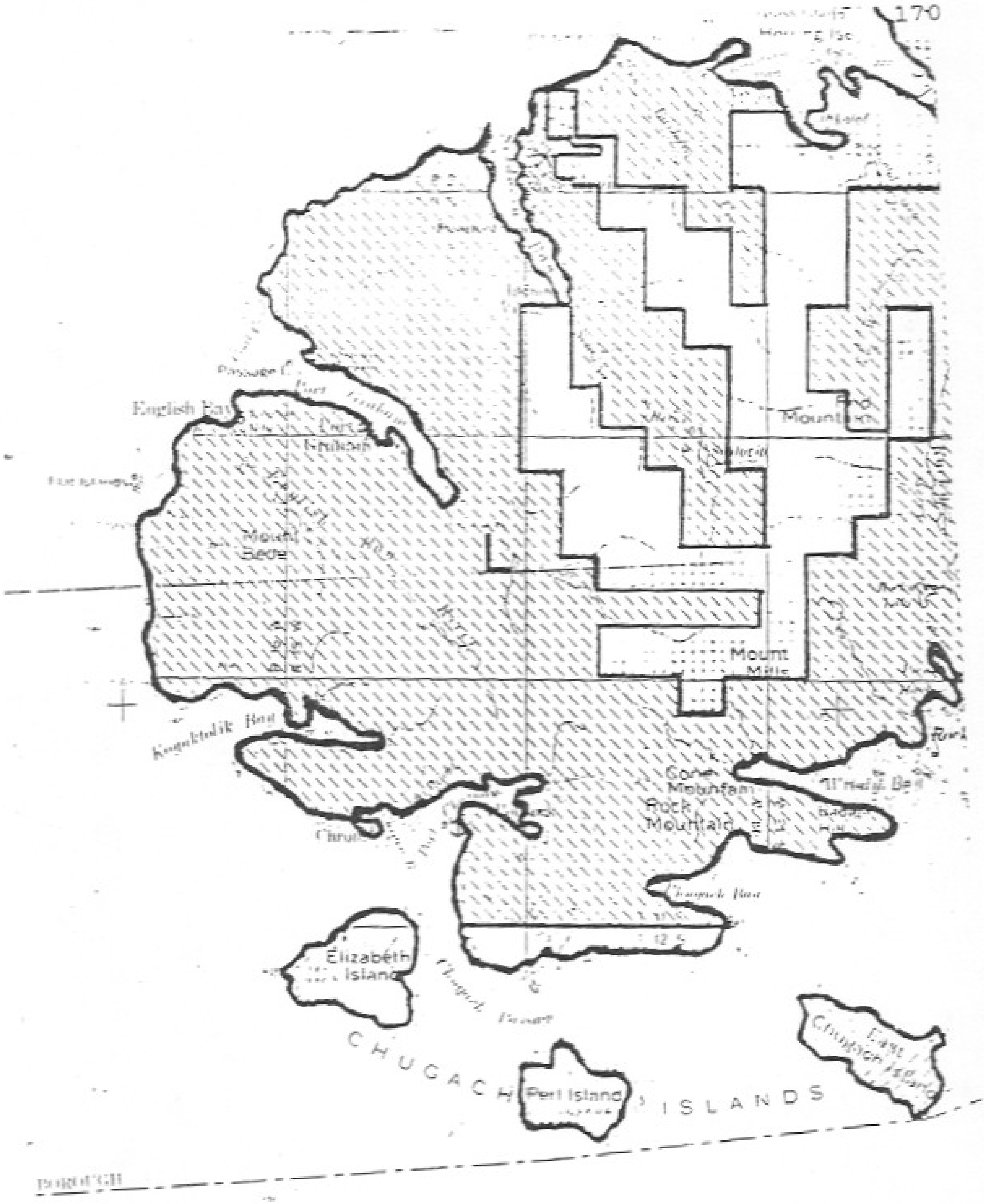


K
G
Callisto
KENAI MOUNTAINS
Northwestern Lagoon
Holgate Arm
AIALIK BAY
Aialik Peninsula
RESURRECTION
Cheval Island
Harris Bay
Harbor Island
Natoa Island
Granite Island
Dora Passage
Two Arm Bay
Matushka I.
Granite Cape
Slate I.

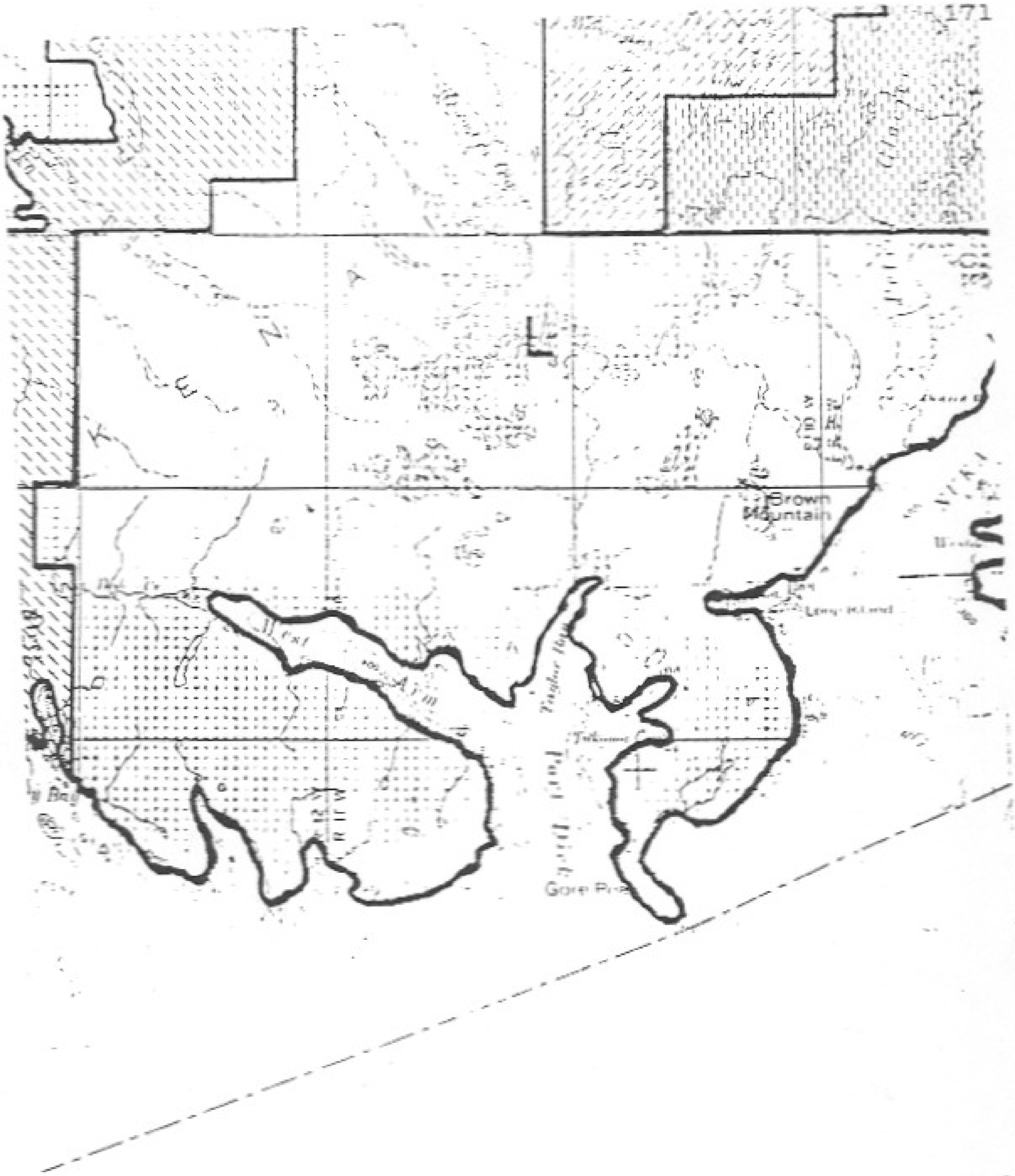
Map III-4


169
H
Resurrection
Peninsula
Day Harbor
Eldorado Narrows
Whidbey
Bay
Cape
Fairfield
Pt Fairfield
Joe
Mansfield
KENAI PENINSULA BOROUGH
Barwell

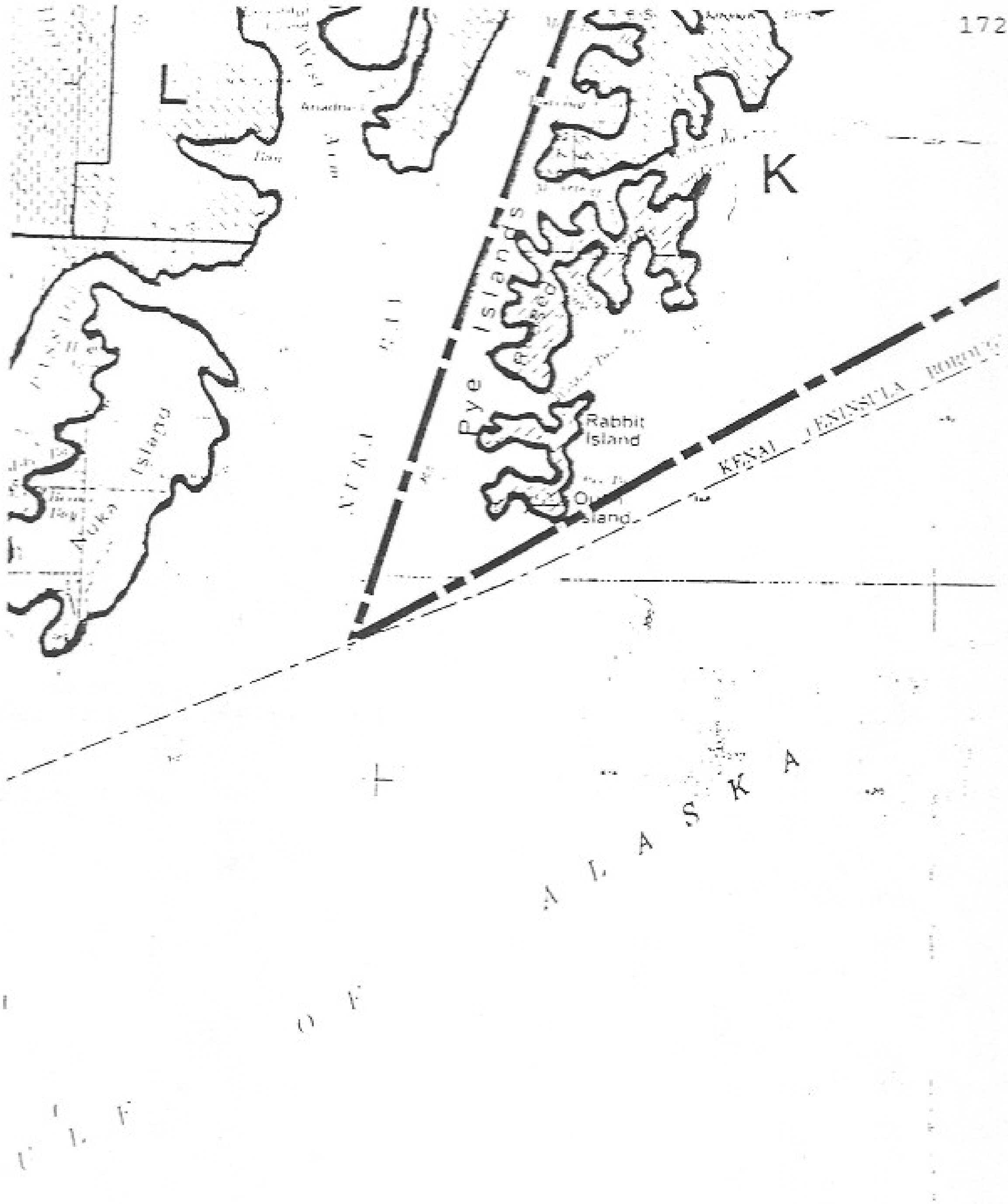
Map III-5


170
English Bay
Port Graham
Mount Bede
Red Mountain
Mount Mills
Cone Mountain
Rock Mountain
Elizabeth Island
Perl Island
East Chugach Island
CHUGACH ISLANDS
Chugach Bay
BOROUGH

Map IV-1



Map IV-2


L
K
Pye Islands
Rabbit Island
Outer Island
Nuka Island
KENAI PENINSULA BOROUGH
ALASKA
GULF OF

Map IV-3

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Appendix A

HOME RANGE MAPS FOR KENAI PENINSULA BROWN BEARS

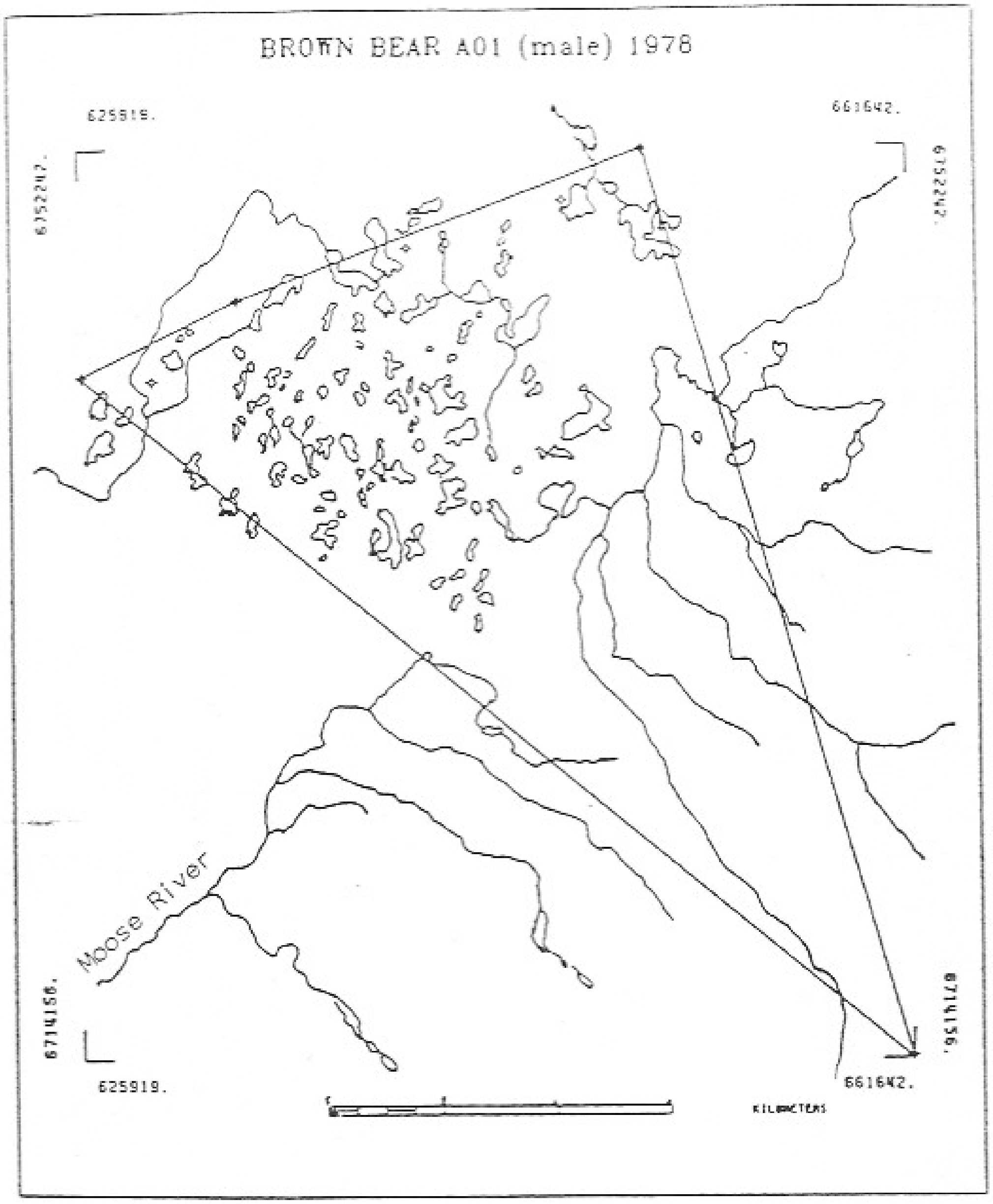

Fig. A1. Home range map of MA01 (+ radio locations).

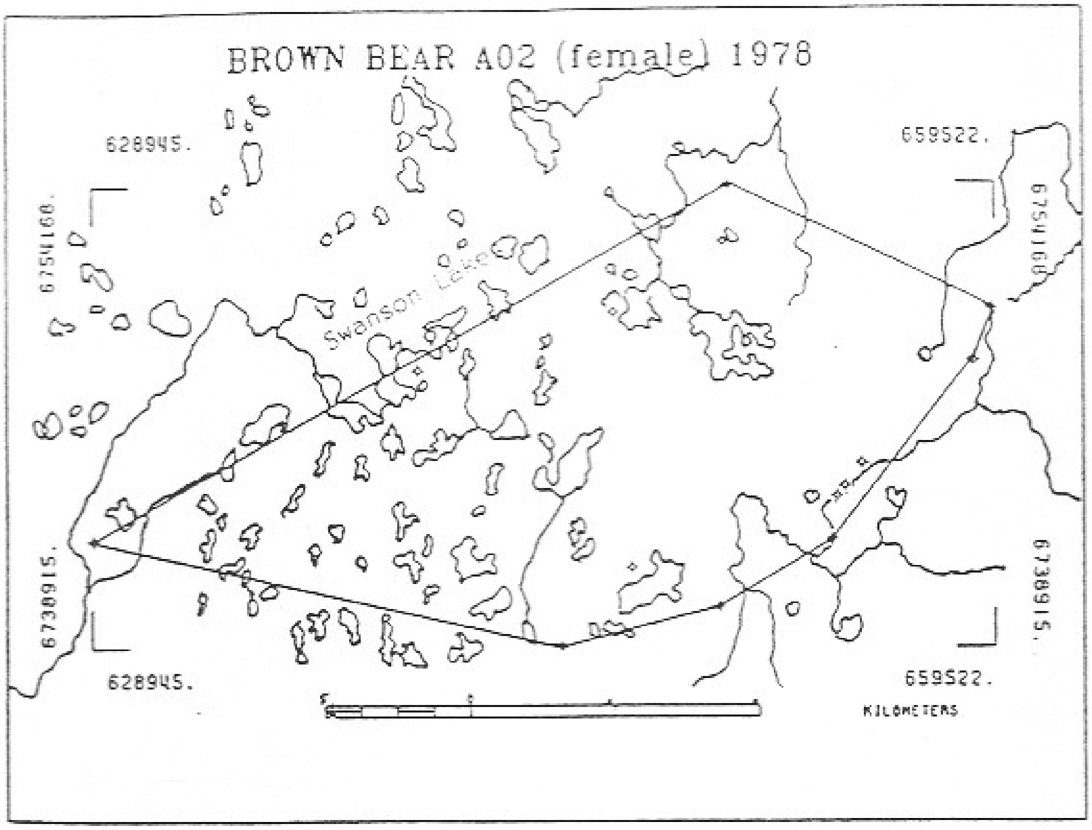

Fig. A2. Home range map for FA02 (◆ radio locations).

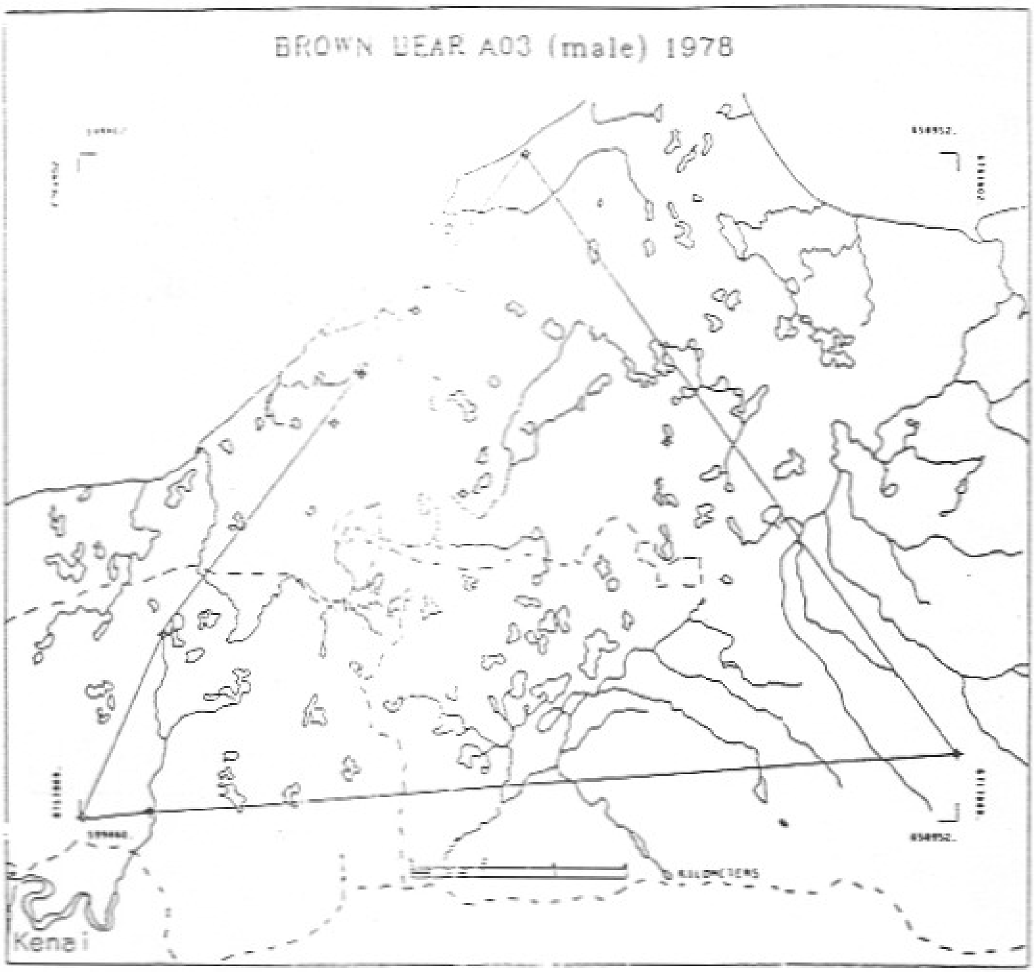

Fig. A3. Home range map for MA03 (◦ radio locations).

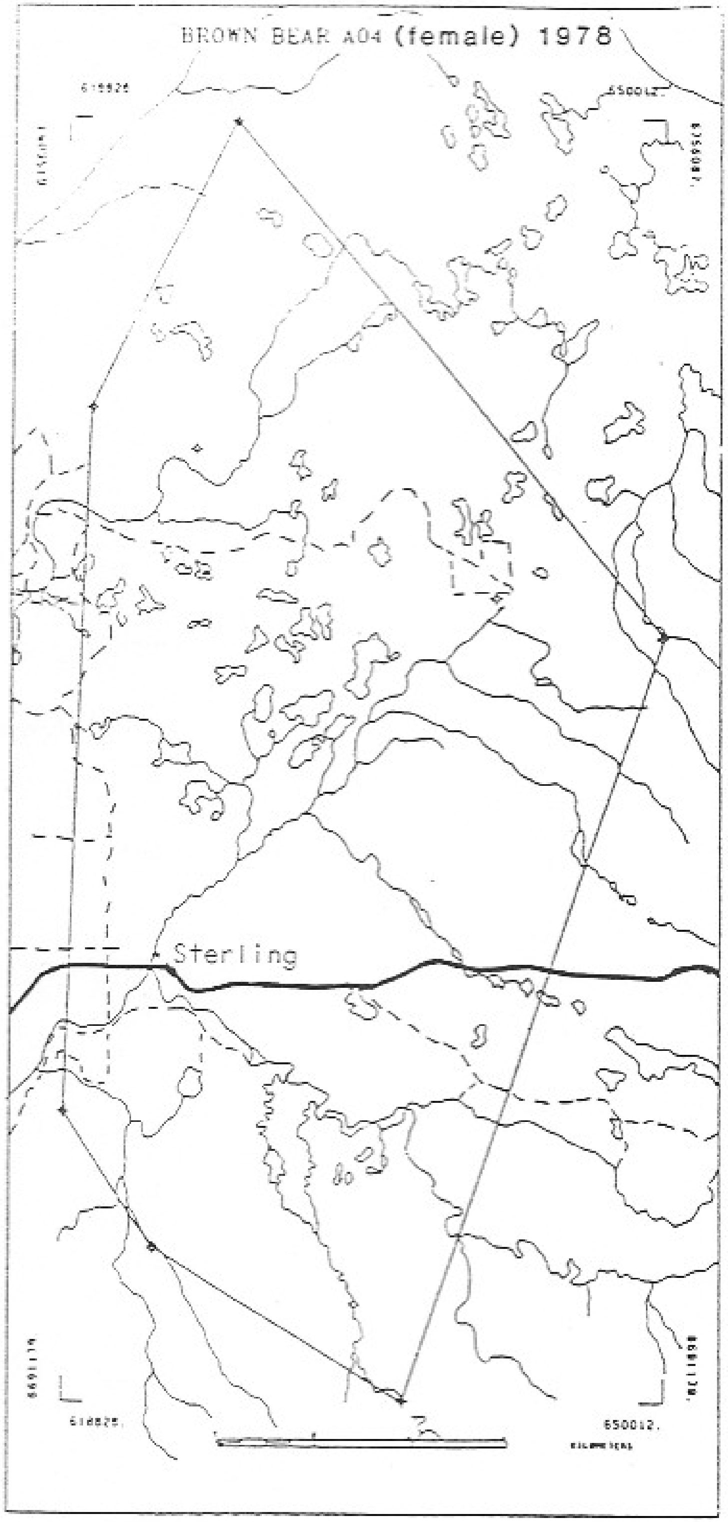

Fig. A4. Home range map for FA04 (◆ radio locations).

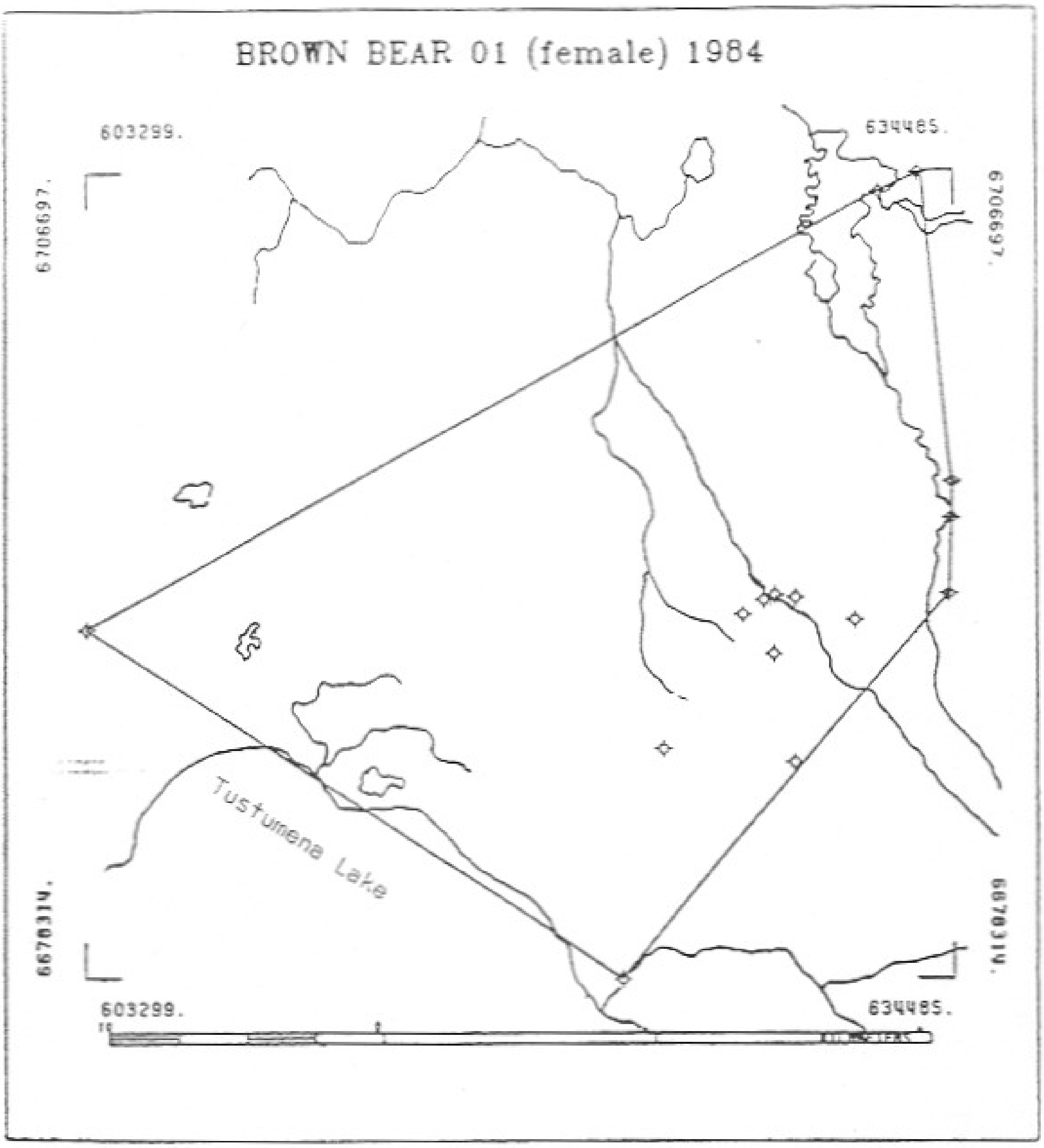

Fig. A5. Home range map for F001 (◇ radio locations).

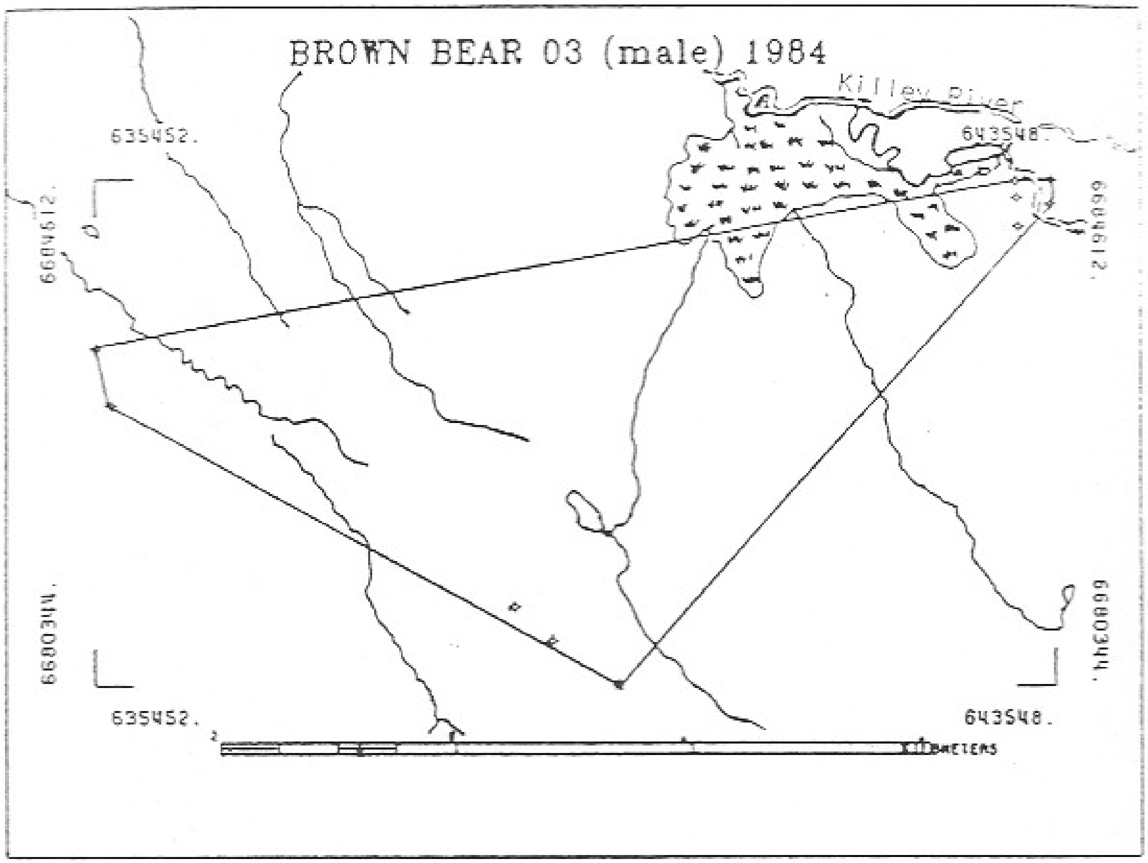

Fig. A6. Home range map for M003 (◊ radio locations).

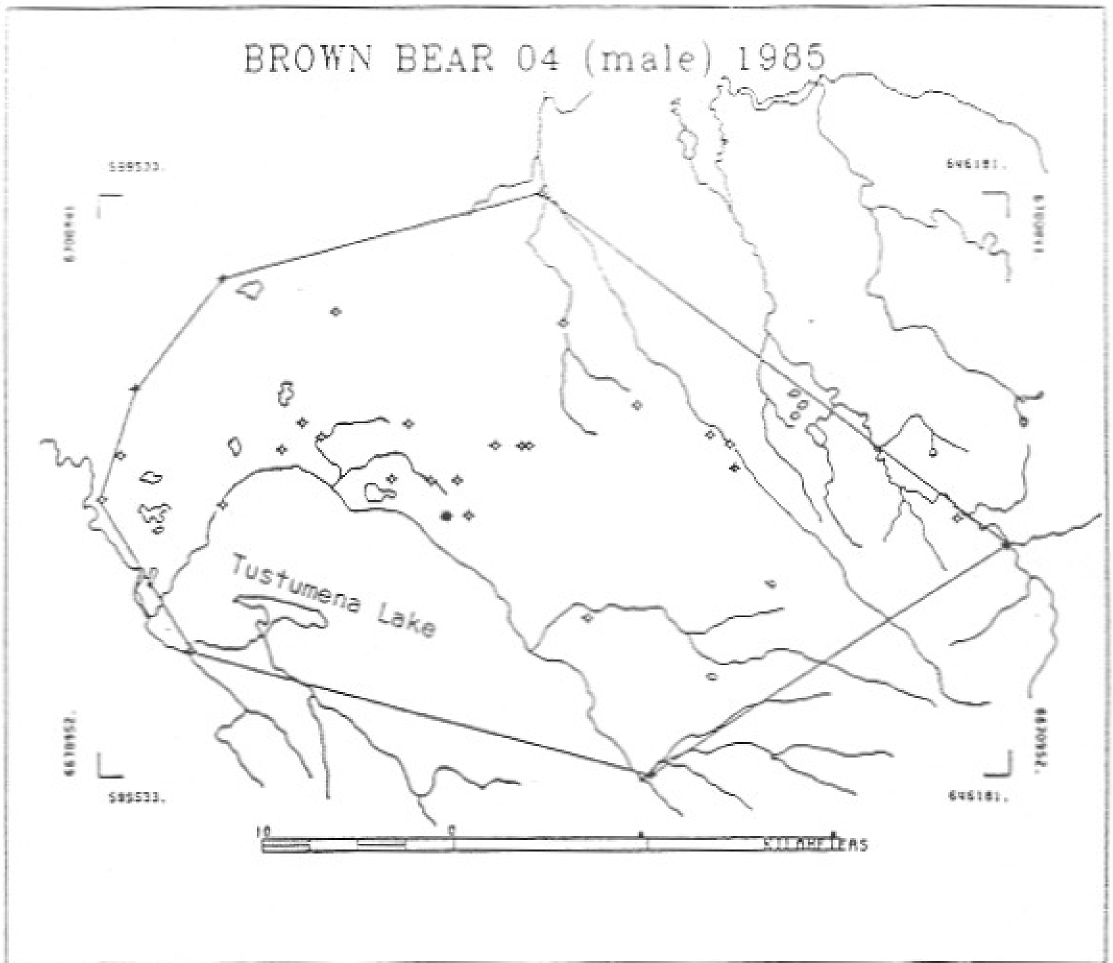

Fig. A7. Home range map for M004 (⋄ radio locations, * den location).

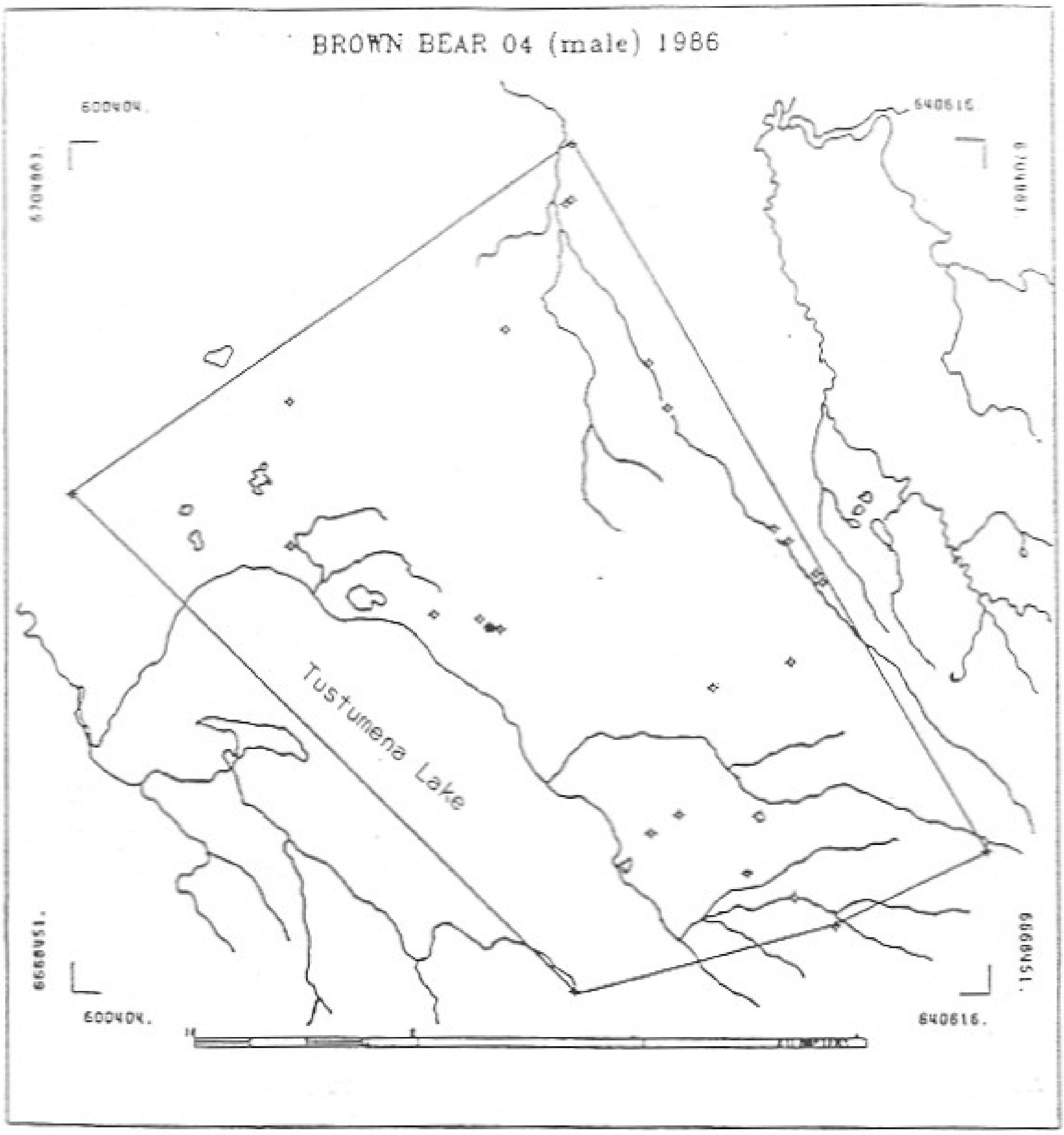

Fig. A8. Home range map for M004 (+ radio locations, * den location).

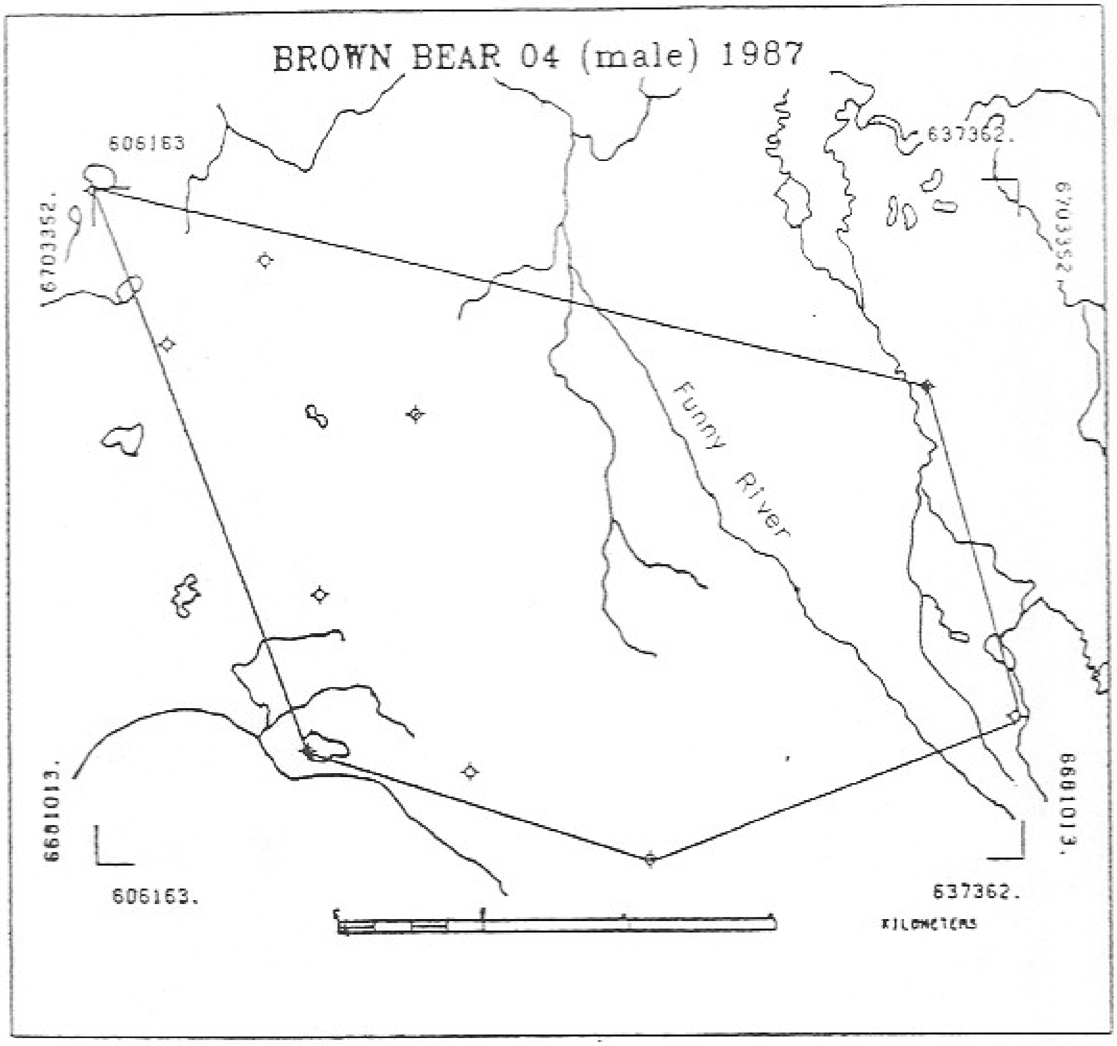

Fig. A9. Home range map for M004 (◇ radio locations).

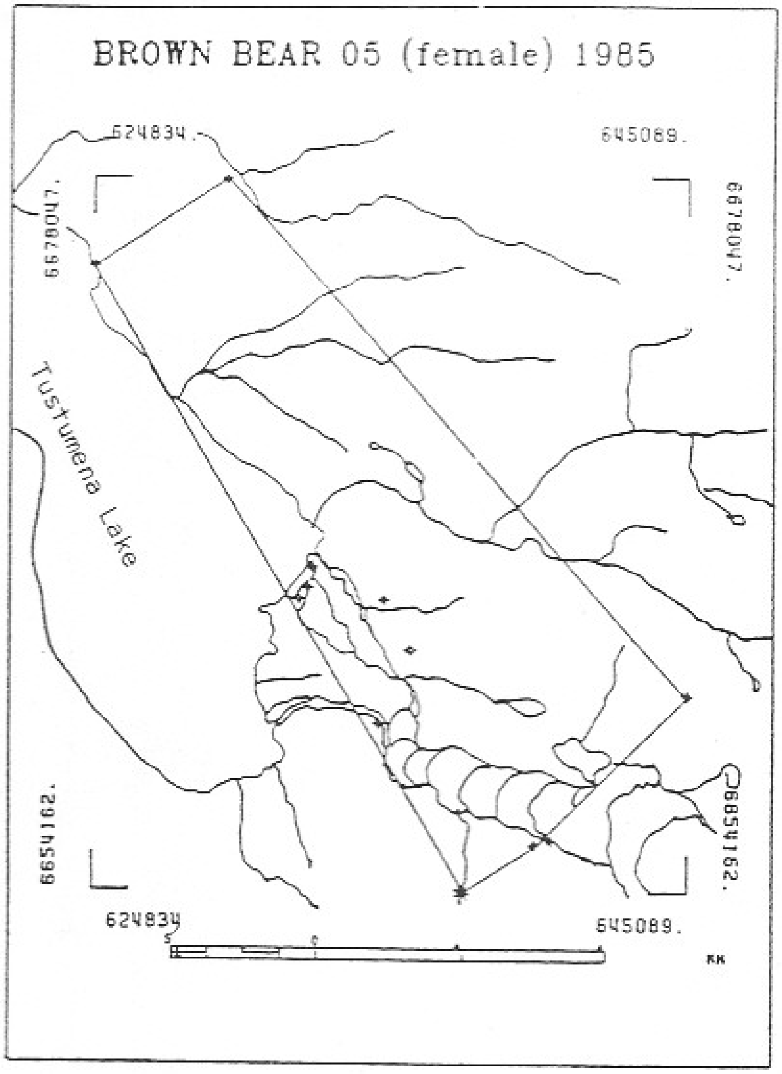

Fig. A10. Home range map for F005 (+ radio locations, * den location).

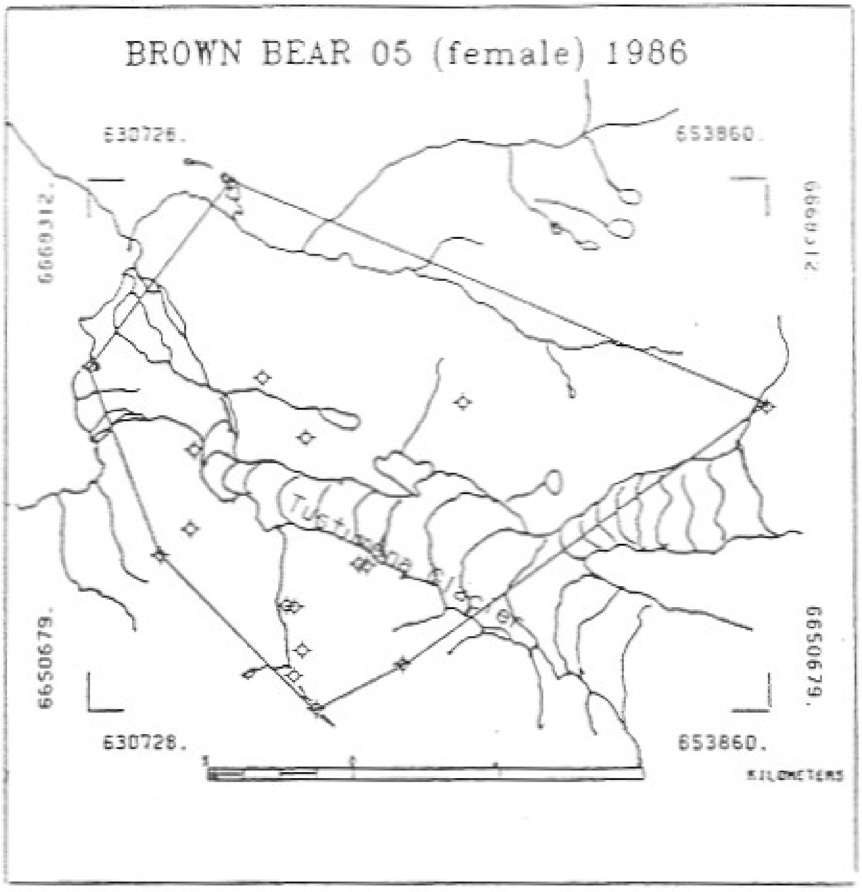

Fig. A11. Home range map for F005 (◇ radio locations).

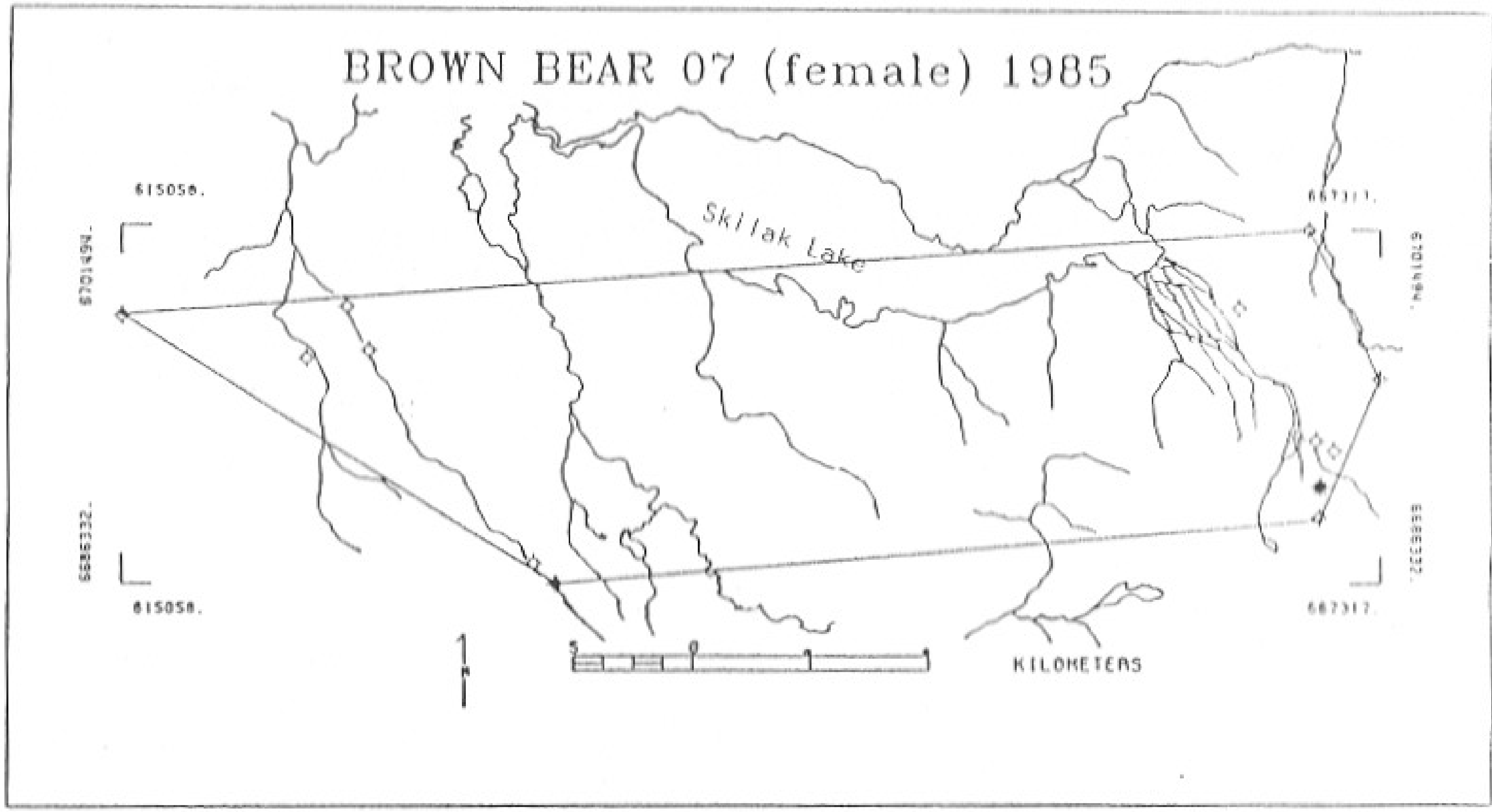

Fig. A12. Home range map for F007 (◇ radio locations, ✱ den location).

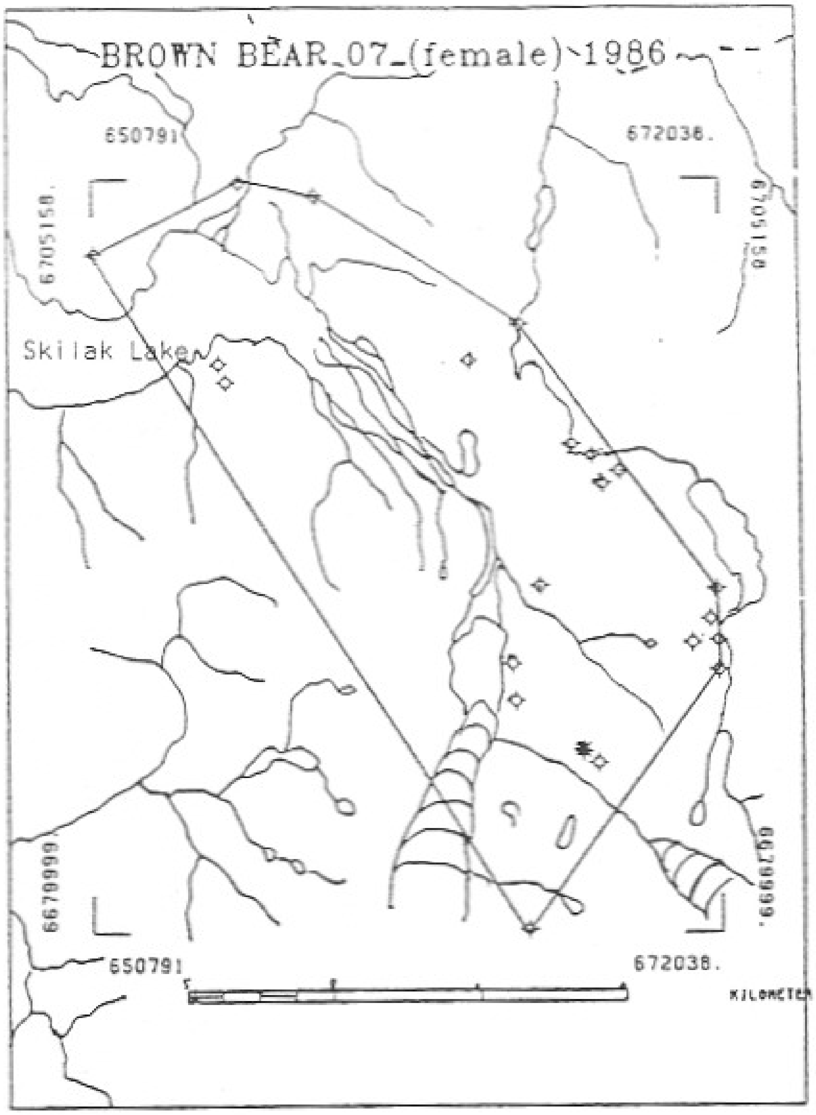

Fig. A13. Home range map for F007 (◇ radio locations, ✱ den location).

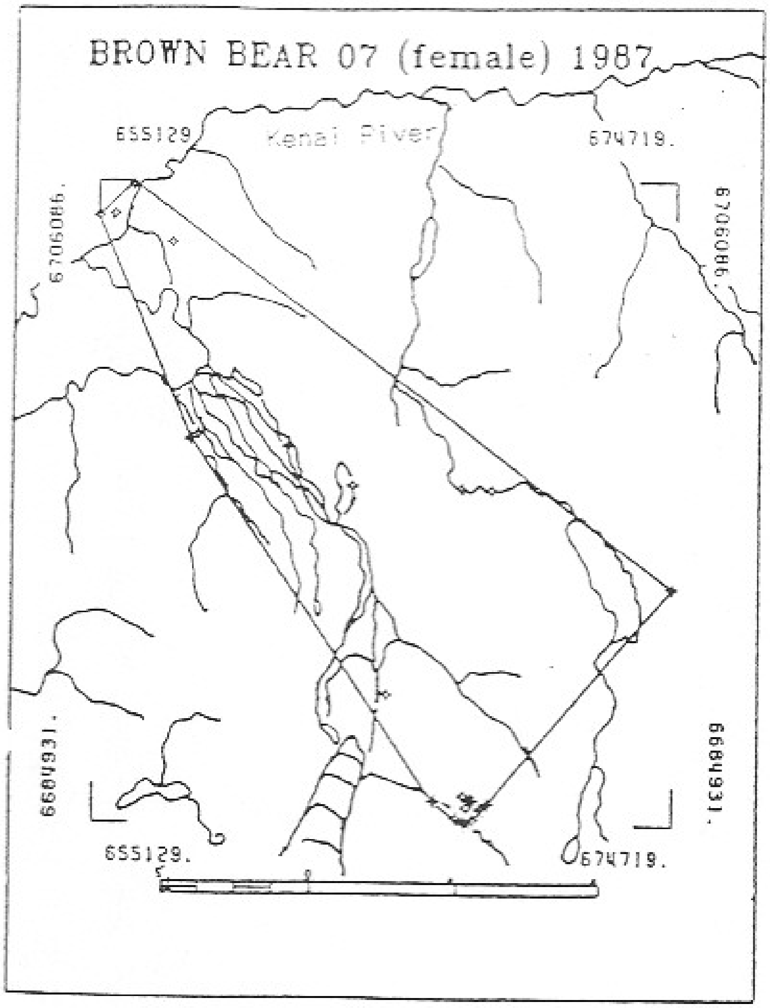

Fig. A14. Home range map for F007 (◇ radio locations, * den location).

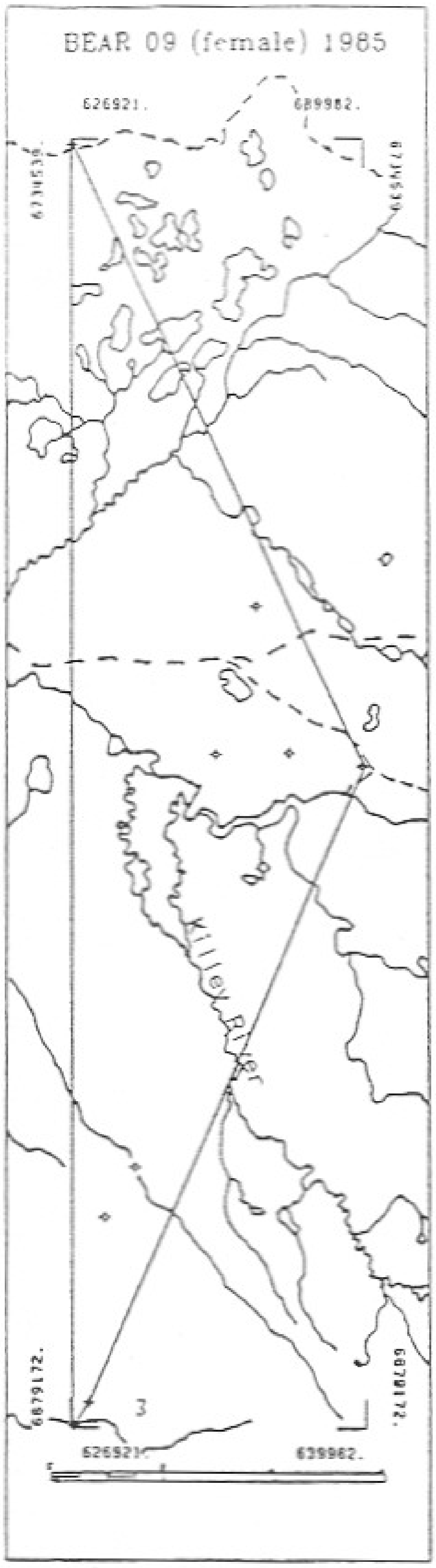

Fig. A15. Home range map for F009 (+ radio locations).

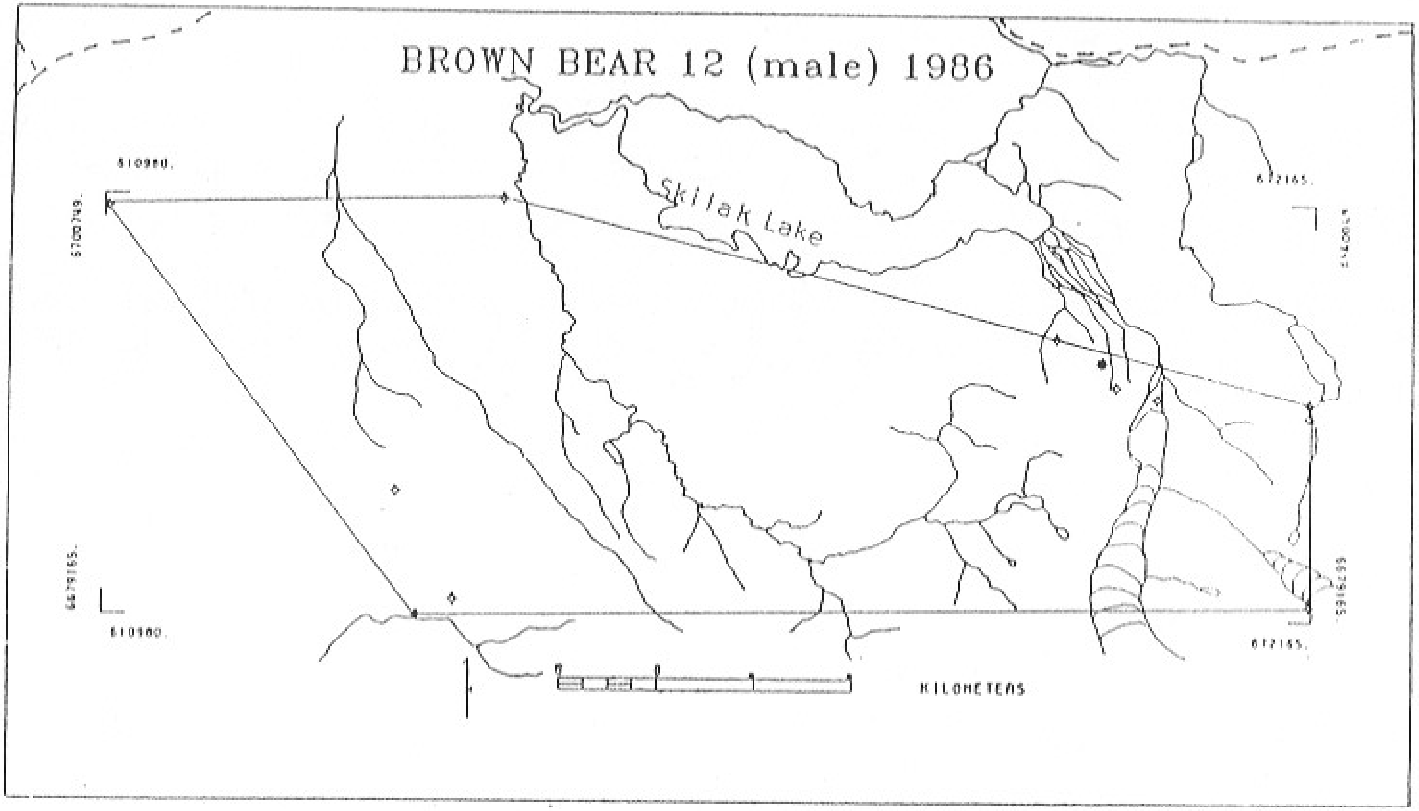

Fig. A16. Home range map for M012 (◇ radio locations, * den location).

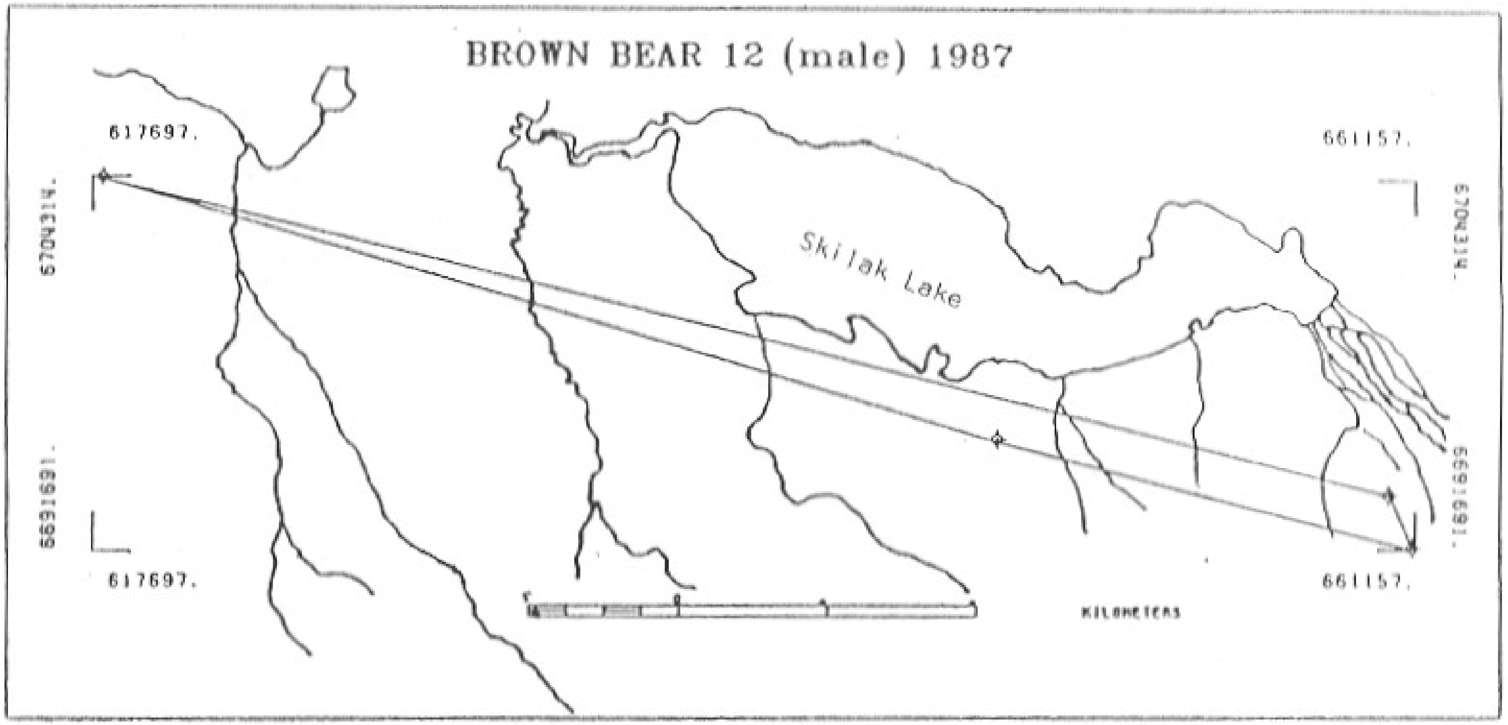

Fig. A17. Home range map for M012 (◊ radio locations).

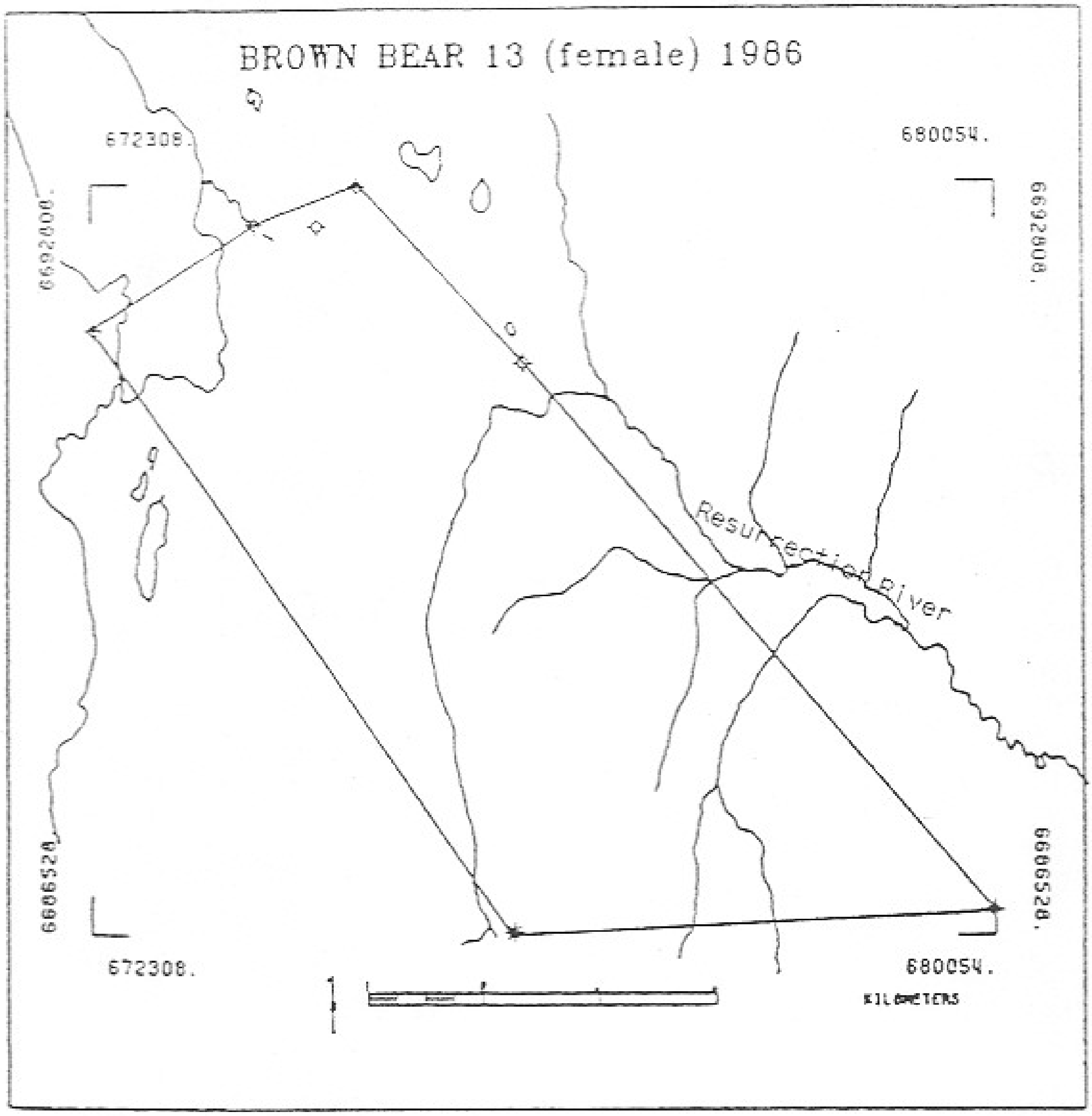

Fig. A18. Home range map for F013 (◇ radio locations, ✱ den locations).

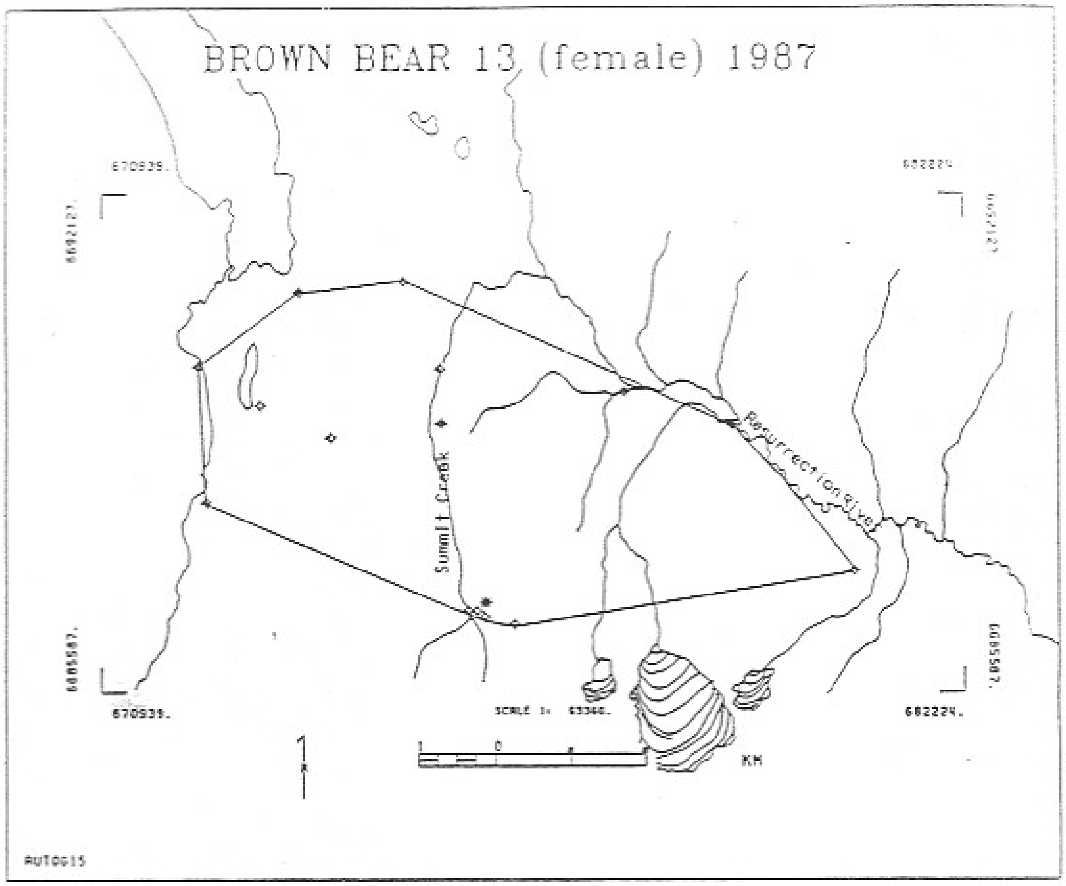

Fig. A19. Home range map for F013 (⋄ radio locations, * den location).

APPENDIX B

BEAR OBSERVATION DATA COLLECTED FROM 1984 THROUGH 1987

(1) Observations by state or federal employees and verified public sightings.

Ground Observations Russian/Cooper/Resurrection Trail System

YEAR	SINGLE BEARS	FEMALES W/(CUBS)	FEMALES W/(YEARL)	FEMALES W/(SUBADULT)	PAIRS
1984	3	0	0	0	0
1985	5	3(4)	0	0	2
1986	7	1(3)	0	1(2)	0
1987	3	0	2(4)	0	0
TOTAL	18	4(7)	2(4)	1(2)	2

AVERAGE NUMBER OF CUBS PER FEMALE = 1.75 n=4
AVERAGE NUMBER OF YEARLINGS PER FEMALE = 2.00 n=2
AVERAGE NUMBER OF SUBADULTS PER FEMALE = 2.00 n=1

Aerial Surveys conducted by USFWS and ADF&G

YEAR	SINGLE BEARS	FEMALES W/(CUBS)	FEMALES W/(YEARL)	FEMALES W/(SUBADULT)	PAIRS
1984	21	5(9)	2(2)	2(3)	0
1985	17	6(10)	3(8)	4(10)	0
TOTAL	38	11(19)	5(10)	6(13)	0

AVERAGE NUMBER OF CUBS PER FEMALE = 1.72 n=11
AVERAGE NUMBER OF YEARLINGS PER FEMALE = 2.00 n=5
AVERAGE NUMBER OF SUBADULTS PER FEMALE = 2.10 n=6

Ground Observations for entire Kenai Peninsula

YEAR	SINGLE BEARS	FEMALES W/(CUBS)	FEMALES W/(YEARL)	FEMALES W/(SUBADULT)	PAIRS
1984	6	0	1(1)	0	0
1985	14	3(5)	4(8)	3(4)	4
1986	9	2(2)	1(1)	1(2)	3
1987	7	2(3)	1(1)	1(3)	3
TOTAL	38	7(10)	7(11)	5(9)	10 + 1

AVERAGE NUMBER OF CUBS PER FEMALE = 1.43 n=7
AVERAGE NUMBER OF YEARLINGS PER FEMALE = 1.57 n=7
AVERAGE NUMBER OF SUBADULTS PER FEMALE = 1.80 n=5

(2) Public Observations

Observations by public (unverified)

YEAR	SINGLE BEARS	FEMALES W/(CUBS)	FEMALES W/(YEARL)	FEMALES W/(SUBADULT)	PAIRS
1985	5	2(3)	0	0	2
1986	6	1(3)	1(3)	1(2)	1
TOTAL	11	3(6)	1(3)	1(2)	3

AVERAGE NUMBER OF CUBS PER FEMALE = 2.0 n=3
AVERAGE NUMBER OF YEARLINGS PER FEMALE = 3.0 n=1
AVERAGE NUMBER OF SUBADULTS PER FEMALE = 2.0 n=1

(3) All Observations Pooled (Pulic and State/federal employee)

YEAR	SINGLE BEARS	FEMALES W/(CUBS)	FEMALES W/(YEARL)	FEMALES W/(SUBADULT)	PAIRS
ALL	101	25(42)	15(28)	13(26)	15 + 1

AVERAGE NUMBER OF CUBS PER FEMALE = 1.68 n=25
AVERAGE NUMBER OF YEARLINGS PER FEMALE = 1.87 n=15
AVERAGE NUMBER OF SUBADULTS PER FEMALE = 2.00 n=13

<u>All Litter Classes Pooled</u>

YEAR	FEMALE W/(YOUNG)	AVERAGE LITTER *
All	53(96)	1.81 n=53

* duplicate observations of family groups were possible